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University of Maine.

# Maine Agricultural Experiment Station

ORONO

BULLETIN 229 JULY, 1914

## STUDIES ON OAT BREEDING.

## I. VARIETY TESTS, 1910-1913.

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# BULLETIN 229.

## STUDIES ON OAT BREEDING.

## I. VARIETY TESTS, 1910-1913.[1]

BY

FRANK M. SURFACE AND CLARENCE W. BARBER.

Owing to the shortness of the growing season as well as to other factors, it is not possible for Maine to compete, on a large scale at least, with more southern states in the production of certain crops. For example the growing of field corn on a moderate scale and for home consumption is a very profitable venture for the Maine farmer, yet owing to the small and early varieties which it is necessary to grow he cannot hope to compete with the corn belt of the middle west in the growing of field corn as a "money" crop. On the other hand, there are certain crops to which the climate of Maine is particularly well adapted. Under our conditions of climate and soil, potatoes, sweet corn and apples acquire particular characters of texture and flavor which have made the trade mark "Maine grown" a guarantee of their ready sale at prices well above the general market.

A consideration of the climatic conditions of Maine indicate that of the cereal crops, oats is the one most suitable for this state. The statistics of oat production show that they do best in a northern climate. Oats require cool weather and an abundance of moisture to do their best. They do well on soil that is not too fertile so that fields which are often unprofitable in corn will do well in oats.

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[1]Papers from the Biological Laboratory of Maine Agricultural Experiment Station, No. 67.

The statistics collected by the United States Department of Agriculture show that at the present time oats is one of the most important crops in Maine. According to the current estimate of the Department of Agriculture[2] the value of the 1913 oat crop in Maine was on December 1, $3,080,000. Only two crops, namely, hay and potatoes, exceed oats in the total amount of wealth produced within the state. Further, the average yield per acre of 40 bushels is some ten bushels above the average for the country as a whole. These figures serve to indicate that the crop is well adapted to our conditions.

The ease with which the oat crop can be seeded, its resistence to late frosts, its adaptability to our climate and soil conditions and the high price which the grain brings in the eastern market, recommend it as a profitable crop. More attention to cultural methods and to seed selection are certain to bring greatly increased returns with this crop. Many of the poor yields of oats are due to poor seed.

The acquisition of Highmoor Farm in the summer of 1909 made it possible for the Maine Agricultural Experiment Station to undertake more extensive experiments in plant breeding. For the reasons given above and on account of the importance of the crop to this state, it was proposed to undertake some breeding or seed improvement work with oats.

Three general lines of work have been undertaken with oats. The scope and purpose of these are indicated in the following paragraphs.

1. *Variety tests.* In starting the work with oats the logical thing to do first was to test a considerable number of the existing varieties of oats which have yielded well in other localities. In order to be of any great value such tests must be continued for a number of years. In this way it is hoped to find out which of these existing varieties are most suitable for Maine conditions. In addition to these more immediate results the variety tests furnish material for definite breeding work with this crop as outlined below. Further the continuation of these tests from year to year establishes a standard with which the production of any new strains originated in our breeding work can be compared.

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[2]The Agricultural Outlook, U. S. Dept. of Agr., Farmers' Bulletin No. 570, Dec. 27, 1913.

2. *Pure line selections.* The second and third lines of work have to do with the production of new strains or varieties which will yield better under our conditions. In the pure line selections, individual plants are first selected from the general plots. The following year the grain from each plant is planted in a separate row and each row harvested separately. The next year the grain from the most promising rows is planted in small plots and in the third year this grain, all of which originated from a single plant, is planted in a larger plot and tested under field conditions. In this way it is hoped to obtain some strains which will do better, under our conditions, than any of the existing varieties.

3. *Hybridization.* The third line of work includes the crossing of varieties or strains, each of which are superior in some characters, and then to isolate from the progeny new varieties combining the desirable qualities of both parents.

Aside from the more immediate practical objects in view, as noted above, this work is planned so as to furnish scientific data on general questions of heredity.

The work with oats was begun in the season of 1910. A considerable amount of data on these several lines of work are already in hand. It is expected that the present bulletin, which deals with the results of the variety tests for the past four years, will serve as an introduction to a series of papers dealing with problems of breeding and inheritance in oats. In this paper we shall describe (1) the cultural and experimental methods used in these variety tests, (2) the seed used and the source from which it was obtained, and (3) some of the results of these four years tests.

## Methods.

### Size and location of plots.

For the years 1910, 1911 and 1912 the variety tests were carried out in one-tenth acre plots, usually allowing only one plot to each variety. In the season of 1913 a different method was adopted. On the basis of a series of careful experiments at the Rothamstead Experiment Station in England, Mercer and Hall[3]

[3]Mercer, W. B. and Hall, A. D. The Experimental Error of Field Trials. Jour. of Agr. Science, Vol. IV, Pt. II, pp. 107-132, 1911.

have shown that much more accurate results will be obtained, as to the comparative yield of varieties, if each variety is planted in several small plots located in different parts of the field than if a single large plot is used. The reason is that unless the soil is very uniform one of the large plots may lie in very favorable soil, while another plot may lie in very poor soil. Such differences in soil may more than outweigh any intrinsic differences in the two varieties. On the other hand, if several small plots of the same variety are placed in different parts of the field there is much less chance of all of them falling in very good or very poor soil. Consequently an average of the yield of several small plots will give a better idea of the inherent yielding capacity of the variety.

Accordingly in 1913 each variety was planted in four one-fortieth acre plots. Thus in all there was a tenth acre of each variety grown but instead of being in a single plot it was in four plots placed in widely separated parts of the field. The results with this method have been very satisfactory for the past season and it is proposed to use this method in future variety tests.

The adoption of this method of planting has involved the use of different methods of seeding and harvesting. These will be discussed at the proper places in the following pages.

Figure 53 shows a map of Highmoor Farm on which the location of the oat variety test plots for the years 1910, 1911, 1912 and 1913 are indicated. It will be noted that in general these oat varieties have not been planted on the same piece of land in successive years. In 1912 that portion of the field east of the buildings marked A had been in the 1911 variety test. In all other cases the land had not been in oats the preceding year.

## CHARACTER OF THE SOIL.

The soil of Highmoor Farm varies from a light sandy loam to a medium clay loam. The natural drainage of this land is very good excepting in a few places where the hard-pan subsoil forms pocket-like depressions. With the exception of the 1913 plots the fields on which the oat tests have been carried out are, in the main, a medium loam. The 1913 field is a rather sandy loam and very well drained. In the several years it has not always been possible to avoid the few wet places in the

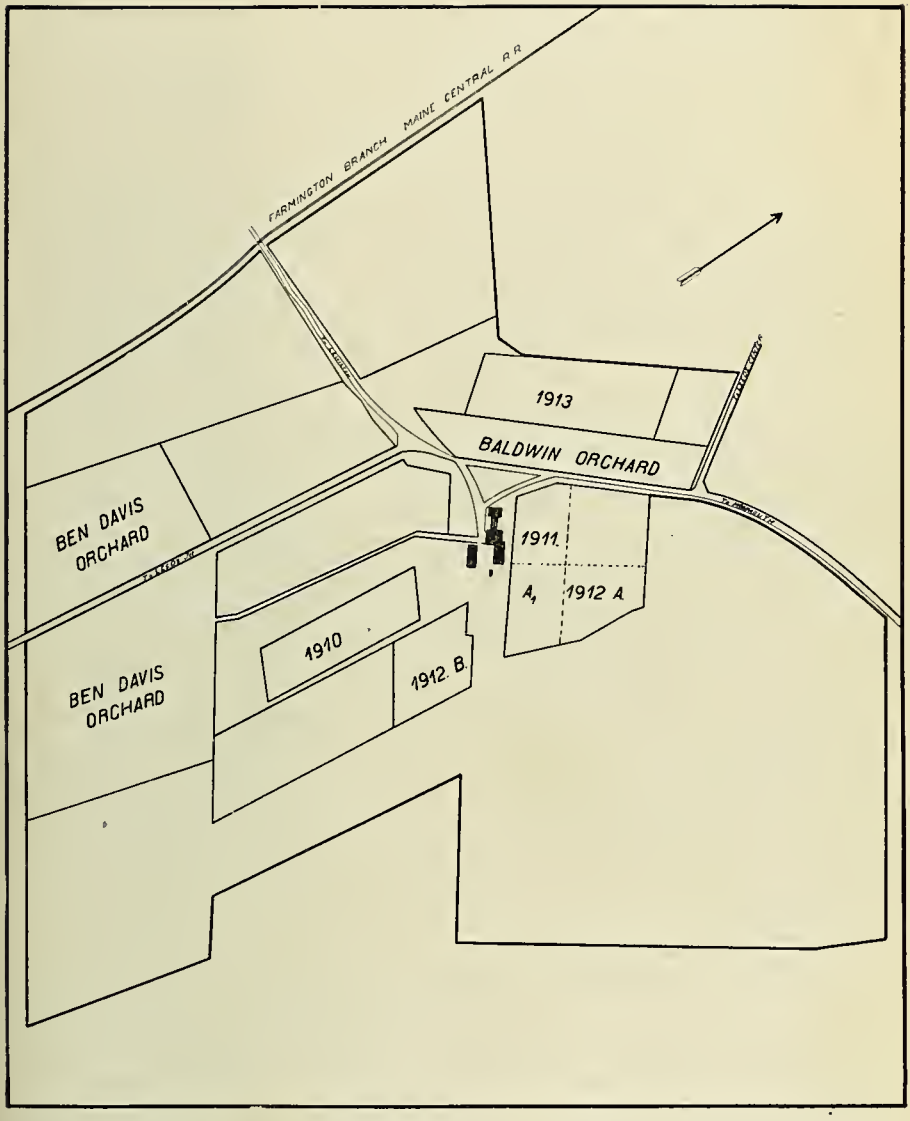



*Fig 53. Outline map of Highmoor Farm showing the location of the oat variety test plots in the years 1910 to 1913 inclusive.*

fields. Further in certain fields there have been ledges coming near the surface of the soil and these have interfered with the yield of certain plots. However, these influences, which have been comparatively slight, have not affected the same variety more than one year. Consequently the average of the four year tests should give a fairly accurate measure of the capacity of a variety to yield under the conditions at Highmoor.

### PREPARATION OF THE LAND.

In the following paragraphs the methods of preparing the land and the amount of fertilizer used are given for each year.

The varieties tested in 1910 were sown on land that had been plowed the previous summer and kept clean by working over about once a week with cutaway and springtooth harrows. Before the farm was placed under the management of the Station this land had laid in sod for many years becoming quite densely infested with witch grass. The summer fallow and clean cultivation resulted in freeing the field from this weed. Immediately before planting the soil was disked with a double action cutaway harrow, going lengthwise and then crosswise of the field. Following this, spiketooth harrows were used to smooth and level the ground in preparation for the seed. At the time of plowing 5½ cords of manure were put on each acre and at the time of seeding 900 lbs. of a fertilizer containing 3.3 percent of nitrogen, 10 percent of available phosphoric acid and 7 percent potash were applied to the 31 tenth-acre plots in the variety tests of this year. The location of these plots is shown in Fig. 53.

In 1911 the variety tests of oats were carried out on land which produced potatoes in the season of 1910. This land was plowed in the fall of 1910 and at that time eight cords of manure were added. This was thoroughly disked in. In the spring of 1911 the ground was again disked by means of cutaway harrows, the harrowing being done crosswise and lengthwise of the field. To smooth and level the field, spiketooth harrows were used. At the time of seeding fertilizer analyzing 4 per cent of nitrogen, 8 percent of phosphoric acid, and 7 percent of potash was applied at the rate of 500 lbs. per acre. As in the year 1910, seed and fertilizer were sown by means of a grain drill.

In 1912 each variety of oats was planted in duplicate. One one-tenth acre plot was sown in field A in the north half of the farm and its duplicate in field B in the south half. (cf. Fig. 53). Field B being better drained was ready for seeding before field A. Field B produced potatoes in 1911 and in preparation for the oat variety tests was plowed in the fall of that year. Before planting this field was thoroughly harrowed twice, once lengthwise and once crosswise, with cutaway harrows. Then smoothing and leveling of the land was accomplished by using spiketooth harrows. The soil is a medium loam, one which works up in excellent shape becoming mellow and finely pulverized. Such preparation makes a splendid seed bed. With the exception of one small area this field is naturally well drained, having a good slope so that no water stands on the surface.

Field A is not so quickly drained as field B and as a result could not be harrowed and seeded until nearly three weeks later. This field comprises practically the same soil conditions as field B. This field was harrowed three times with springtooth harrows finally smoothed and leveled with spiketooth harrows. Owing to the frequent heavy rains and lateness of the season for seeding oats the soil could not be worked into the most mellow and desirable condition for a seed bed.

Each of these fields was fertilized at the rate of 500 lbs. per acre of a high grade fertilizer containing 4 percent nitrogen, 8 percent phosphoric acid and 7 percent potash. In past seasons the fertilizer had been applied in the drill at the time of seeding. This year the fertilizer was broadcasted and harrowed in before planting.

In 1913 the variety test plots were located in the light sandy field to the north of the Baldwin orchard (cf. Fig. 53). This field slopes rather sharply towards the northwest. In 1910 this field was planted in oats without fertilizer of any kind in order to test the uniformity of the soil. In 1911 a crop of buckwheat was turned under for green manure. In 1912 this field was in potatoes. The field was plowed in the fall of 1912. In the spring of 1913 the ground was harrowed several times with springtooth harrows. Owing to the light soil this was sufficient to produce a good seed bed. Just before seeding the field was fertilized at the rate of 650 lbs. per acre of a 4-8-7 fertilizer.

the same as used on the oat plots in the two preceding seasons. The fertilizer was broadcasted and harrowed in before seeding as in the previous year.

### TREATMENT OF THE SEED.

Each year all the grain raised at Highmoor is recleaned and graded before it is sown or offered for sale. The cleaning is done with an ordinary fanning mill. This removes all the light, unfilled or immature grains. This practice is undoubtedly of great value and if it were followed by the farmers of the state it would result in better stands and better grain.

Just before sowing the oats are treated with a formalin solution to kill the loose smut spores which may be clinging to the grain. In this treatment a bag containing the oats is immersed for twenty minutes in a solution containing one pint of commercial formalin (40 percent) to 50 gallons of water. The oats are then spread out to dry so that they may be sown in the drill. This method has proved very successful. There have been practically no smutted heads in any of our plots.

### SHAPE OF PLOTS AND METHODS OF SEEDING.

The shape of the one-tenth acre plots varied in different years according to the fields upon which they were planted. In general the length of these plots was always several (5 to 12) times its width. On the other hand the one-fortieth acre plots were all in the form of a square, each side of which was 33 feet long. It has been the practice in most variety tests in this country to use long narrow plots. If, as is usually the case, cultivated pathways are allowed between these plots the plants on the margin grow much more vigorously than those in the interior. In the case of small plots the total yield may be very greatly affected by the proportionate number of these marginal plants. It has recently been shown by one of us[1] that the marginal area is reduced to a minimum in plots in the form of a square. In such plots there is much less chance for the yield to be affected

[1]Barber, C. W. Note on the Influence of Shape and Size of Plots in Tests of Varieties of Grain. Ann. Rept. Maine Agr. Expt. Stat. 1914. pp. 76-84. (Bulletin No. 226).

by the more vigorous growing marginal plants than in the case of long and narrow plots. A plot in the form of a square more nearly approaches the conditions found in a general field than a plot of equal size in any other shape.

All of the grain sown at Highmoor in plots of 1-10 acre or larger is planted in drills seven inches apart by means of a large disk grain drill. This machine drops the seed under forced feed. Eleven rows are planted at a time. This method of seeding insures that the grain is covered at an even depth and gives a much more even stand than does the usual method of broadcasting.

In the case of fortieth acre plots in the form of a square it is obviously impossible to use a large drill. In these plots the ground is first thoroughly prepared and then marked off in rows six inches apart. The grain is then planted with a small hand drill which plants one row at a time. Three of these drills were used in planting the 1913 plots.

The rate of seeding has been uniformly two bushels per acre for each variety in each year. However, in 1910 the rate was two bushels by measure, while in 1911, 1912, and 1913 it was two bushels by weight. For many varieties characterized by large grains two bushels per acre does not give a sufficient stand. The basis for seeding oats should take into account the number of grains per bushel. However, the four year test of these varieties with uniform rate of seeding gives us a kind of data that could not be obtained by other methods.

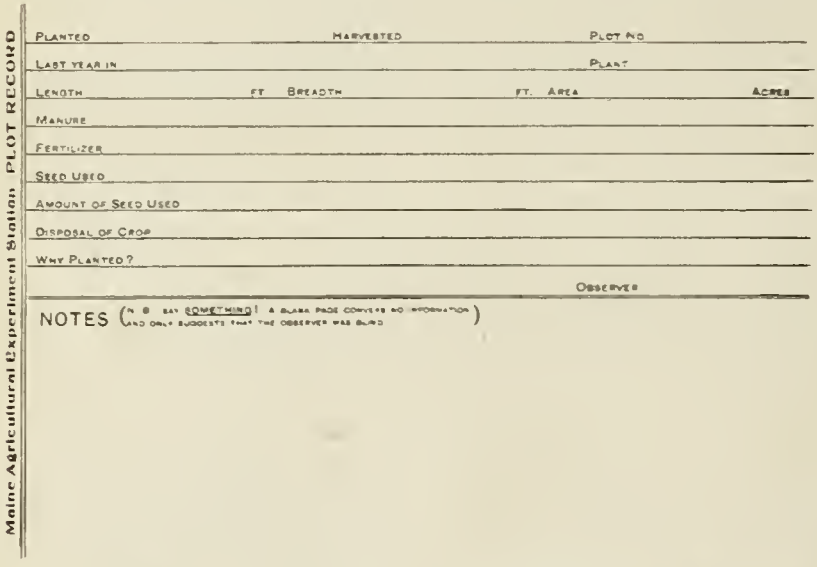
## HARVESTING AND THRESHING.

The general practice in harvesting has been to allow the grain to mature as much as possible without shattering. This means that the plants will have lost practically all the green color and the grain will be fairly hard. In the case of the larger plots it is then cut with a binder, shocked and allowed to dry. On the fortieth acre plots it is necessary to cut the grain with a cradle and bind it by hand. When completely cured each plot is hauled to the scales and threshing machine. In order to facilitate handling the grain from the fortieth acre plots, large canvasses 12 x 12 feet were used to wrap around all the grain from a single plot. In this way a number of small plots could be hauled at once without danger of mixing the grain.

The threshing machine used is the so-called Baby Vibrator, made by the A. B. Farquhar Company. This machine has a 12 inch cylinder. In threshing a series of small plots containing different varieties it is necessary to see that the machine is thoroughly cleaned after each plot. If this is not done the varieties very soon become badly mixed. In order to facilitate cleaning it has been necessary to remodel this machine in several respects so that now it is possible to open up all parts of the machine and remove any lodged grain after threshing each plot.

## RECORDS.

An important element in this kind of experimental work is the keeping of accurate notes about each variety. To facilitate this work we have devised a system of printed loose leaf blanks.


Maine Agricultural Experiment Station PLOT RECORD

PLANTED _____ HARVESTED _____ PLOT NO _____

LAST YEAR IN _____ PLANT _____

LENGTH _____ FT. BREADTH _____ FT. AREA _____ ACRES

MANURE _____

FERTILIZER _____

SEED USED _____

AMOUNT OF SEED USED _____

DISPOSAL OF CROP _____

WHY PLANTED? _____

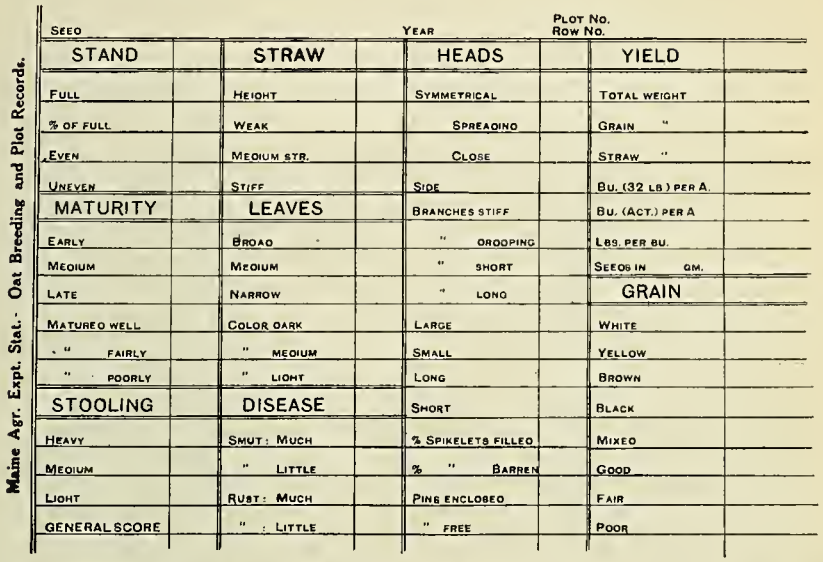
OBSERVER _____

NOTES (N. B. SAY SOMETHING! A BLANK PAGE CONVEYS NO INFORMATION AND ONLY SUGGESTS THAT THE OBSERVER WAS BLIND)

*Fig. 54. Facsimile of Plot Record sheet used in the oat variety tests.*

Figure 54 shows a facsimile of the Plot Record blank. This blank, which may be used for any crop, provides for the size of plot, fertilization, seed used and for general notes about the plot.

Figure 55 shows a facsimile of the blank on which data regarding the straw, leaves, heads, grain, yield, disease resistance, etc., are recorded.


Maine Agr. Expt. Stat.- Oat Breeding and Plot Records.

| Seed | | | Year | | Plot No. Row No. | |
|---|---|---|---|---|---|---|
| STAND | | STRAW | | HEADS | | YIELD | |
| Full | | Height | | Symmetrical | | Total weight | |
| % of full | | Weak | | Spreading | | Grain " | |
| Even | | Medium str. | | Close | | Straw " | |
| Uneven | | Stiff | | Side | | Bu. (32 lb.) per A. | |
| MATURITY | | LEAVES | | Branches stiff | | Bu. (Act.) per A | |
| Early | | Broad | | " drooping | | Lbs. per bu. | |
| Medium | | Medium | | " short | | Seeds in gm. | |
| Late | | Narrow | | " long | | GRAIN | |
| Matured well | | Color dark | | Large | | White | |
| " fairly | | " medium | | Small | | Yellow | |
| " poorly | | " light | | Long | | Brown | |
| STOOLING | | DISEASE | | Short | | Black | |
| Heavy | | Smut: Much | | % Spikelets filled | | Mixed | |
| Medium | | " Little | | % " Barren | | Good | |
| Light | | Rust: Much | | Pins enclosed | | Fair | |
| GENERAL SCORE | | " : Little | | " free | | Poor | |

*Fig. 55. Facsimile of Oat Breeding record used in the oat variety tests.*

Finally Figure 56 shows the plot index. Plot numbers are never duplicated so that by the use of this index it is possible to trace back the pedigree of any strain. This same blank is used for all plant breeding work. Hence, in the third column, under the heading "Plant," the kind of crop, whether oats, corn, beans, etc., is indicated. Under the heading "Seed used" there is given both the variety and the source of the seed.

In 1910 the variety tests were under the supervision of one of the writers (F. M. Surface). In 1911 the tests were in charge of Dr. E. P. Humbert, at that time Associate Biologist in the Station. In 1912 and 1913 the tests were again under the supervision of one of the writers (C. W. Barber). To Dr. Raymond Pearl is due the credit for the continuity of these tests during the several years and for many suggestions during the course of the work.

## Varieties Tested.

The number of commercial varieties of oats appears to be unlimited. In a great many cases the chief difference between these so-called varieties is in the name. On the other hand, there are a number of distinct varieties separated from each other by marked morphological or physiological characters. The remaining so-called varieties are simply strains selected out of one of the fundamental varieties. Many of these strains are characterized by stiffer straw or greater yield than that of the mother variety. Inasmuch as these strains tend to breed true to these characters it is perhaps justifiable to designate them as separate varieties.

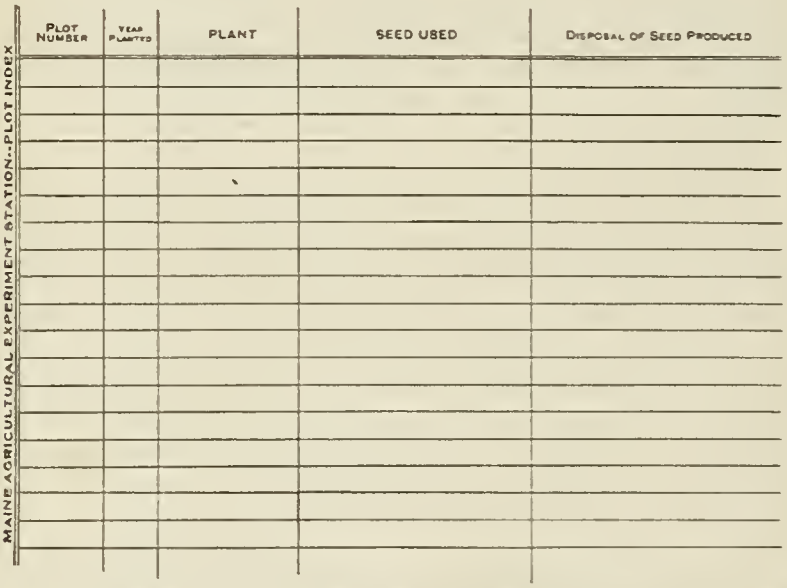



*Fig. 56. Facsimile of Plot Index sheet used in the plant breeding work.*

Table 1 gives the name and the source of the seed of all the varieties which have been tested at any time in the past four years. In some cases several strains of the same variety were obtained from different sources. In general only one such strain of a variety has been continued after the first year. Several varieties appeared to be so poorly adapted to our conditions that they have been dropped after one or two years' trial.

## TABLE I.

### *Varieties Tested.*

| Variety introduced in | Accession number. | VARIETY NAME. | SEED PURCHASED FROM |
|---|---|---|---|
| 1910 | 1 | Danish Island | W. A. Burpee, Philadelphia, Pa. |
| 1910 | 2 | Burpee's Welcome | W. A. Burpee, Philadelphia, Pa. |
| 1910 | 3 | White Tartar King | W. A. Burpee, Philadelphia, Pa. |
| 1910 | 4 | Tartar King | J. Levasseur, Tessierville, Que. |
| 1910 | 5 | Black Tartarian | Iowa Seed Company, Des Moines, Iowa. |
| 1910 | 6 | Kherson (Univ. No. 1) | Griswold Seed Company, Lincoln, Nebr. |
| 1910 | 7 | Kherson | Iowa Seed Company, Des Moines, Iowa. |
| 1910 | 8 | Irish Victor | Iowa Seed Company, Des Moines, Iowa. |
| 1910 | 9 | Early Champion | Iowa Seed Company, Des Moines, Iowa. |
| 1910 | 10 | Prosperity | Iowa Seed Company, Des Moines, Iowa. |
| 1910 | 11 | Silver Mine | Iowa Seed Company, Des Moines, Iowa. |
| 1910 | 12 | Lincoln | Iowa Seed Company, Des Moines, Iowa. |
| 1910 | 13 | Regenerated Swedish Select | Garton-Cooper Company, Chicago, Ill. |
| 1910 | 14 | Regenerated Swedish Select | Griswold Seed Company, Lincoln, Nebr. |
| 1910 | 15 | Regenerated Swedish Select | L. L. Olds, Company, Madison, Wis. |
| 1910 | 16 | Swedish Select | L. L. Olds, Company Madison, Wis. |
| 1910 | 17 | President | Garton-Cooper Company, Chicago, Ill. |
| 1910 | 18 | Senator | Garton-Cooper Company, Chicago, Ill. |
| 1910 | 19 | Victor | Garton-Cooper Company, Chicago, Ill. |
| 1910 | 20 | Old Island Black | E. E. Arsenault, Urbinville, P. E. I. |
| 1910 | 21 | White Egyptian | T. J. Wigginton, Bridgetown, P. E. I. |
| 1910 | 22 | Newmarket | C. R. Gies, Heidelburg, Ontario. |
| 1910 | 23 | Imported Scotch | H. L. Goltz, Bardsville, Ontario. |
| 1910 | 24 | Early Blossom | D. Innes, Tabique River, N. B. |
| 1910 | 25 | Unnamed White, Maine grown. | Geo. B. Haskell Co., Lewiston, Maine. |
| 1910 | 26 | Banner | W. H. Pawsen, Cooldale, Alberta. |
| 1910 | 27 | Banner | Geo. Boyce, Meridale, Ontario. |
| 1910 | 28 | Banner | W. M. Black, Creelman, Saskatchewan. |
| 1910 | 29 | Banner | W. E. Palmer, Scotch Lake, N. B. |
| 1910 | 30 | Ligowo | D. Carmichee!, West Lorne, Ontario. |
| 1910 | 31 | Unnamed White, Maine grown | Prof. G. H. Hamlin, Orono, Maine. |
| 1911 | 32 | American Clydesdale, | J. M. Thornburn Co., New York, N. Y. |
| 1912 | 33 | White Plume | L. L. Olds, Company Madison, Wis. |

TABLE 1—Concluded.

| Variety introduced in | Accession number. | VARIETY NAME. | SEED PURCHASED FROM |
|---|---|---|---|
| 1912 | 34 | Rebred 60-day | L. L. Olds Company, Madison, Wis. |
| 1912 | 35 | Daubeney | C. R. Giles, Heidelburg, Ontario. |
| 1912 | 36 | Siberian | Wm. Lewis, Dunsford, Ontario. |
| 1912 | 37 | Abundance | James Furgeson, Dalmeny, Ontario. |
| 1912 | 38 | Gold Rain | Experiment Station, Charlottetown, P. E. I. |
| 1912 | 39 | Minnesota No. 26 | Garton-Cooper Co., Chicago, Ill. |
| 1912 | 40 | Early Pearl | R. L. Copeland, Brewer, Maine. |
| 1913 | 41 | Garton No. 5 | Garton-Cooper Co., Chicago, Ill. |

Of the 41 varieties in this list seven are duplicates in the sense that they are strains of a given variety obtained from different sources. This leaves 34 varieties bearing distinct names.

The general characters of these varieties are shown in Table 2. In this table the varieties used are classified under their chief distinguishing characters.

TABLE 2.

*Classification of the Varieties Tested.*

I. OPEN SPREADING HEAD.
A. Early Oats.

a. White grain.
9*. Early Champion.
35 . Daubeney.

b. Yellow grain.
6-7. Kherson.
34. Rebred 60-day.

B. Medium Early Oats.

a. Yellow grain.
23. Imported Scotch.

C. Medium Late Oats.

a. White grain

11. Silver Mine.
8. Irish Victor.
40. Early Pearl.
12. Lincoln.
2. Burpee's Welcome.
39. Minnesota No. 26.

*The number before the variety name refers to the accession number as given in Table 1.

TABLE 2—Concluded.

25, 31. Unnamed White.
4. Tartar King.
30. Ligowo.
10. Prosperity.
1. Danish Island.
13-16. Swedish Select.
17. President.
26-29. Banner.
36. Siberian.
37. Abundance.
22. Newmarket.

b. Yellow grain.

38. Gold Rain.

c. Black grain.

19. Victor.
20. Old Island Black.

II. CLOSE SIDE HEAD (Horse Mane Oats.)

A. Medium Oats.
a. White grain.
18. Senator.
3. White Tartar King.
21. White Egyptian.
24. Early Blossom.
33. White Plume.

b. Black grain.

5. Black Tartarian.

III. INTERMEDIATE HEAD.

A. Medium oats.
a. White grain.

41. Garton No. 5.

IV. MIXED TYPE.

A. Medium Oats.
a. White grain.
1. American Clydesdale.

It would be very desirable if we could know something of the origin and history of these different varieties. However, in the main it is impossible to learn anything of importance regarding their origin. In the case of certain varieties we do know when they were imported to this country, or occasionally how they arose.

On the following pages there is given a brief description of the more important varieties which we have tested. In some cases notes on the history of the variety will be included. The descriptions of these varieties are based entirely upon our own observations. The reader is reminded that strains of these varieties coming from different sources or grown under different conditions are likely to vary somewhat from the characters given here.

EARLY VARIETIES OF OATS.

*Early Champion.* This is an early oat maturing at about the same time as the Kherson. In our plots it has been ready to cut in from 85 to 90 days after planting. The straw has fine small sized stems showing a tendency to weakness. The average height is about 36 inches. The leaves are narrow, medium green in color. The heads are small, symmetrical, and spreading. The grain is long, slender, and white in color. It resembles the Kherson in all but color.

*Daubeney.* This oat presents practically the same characters as the Early Champion. In our experience the straw is slightly weaker and shows an average height of 30 to 32 inches. The grains are a little more plump than the Early Champion and of a good white color.

*Kherson and Rebred 60-Day.* These two varieties are practically identical in appearance. Both were introduced into the United States from adjoining provinces in southern Russia. The Kherson was introduced in 1896[5] and the 60-day variety in 1901.[6] Both have fine small straw averaging 30 inches in height. In our experience the Kherson straw is slightly stiffer than that of the 60-Day. The leaves are very narrow, and rather light green in color. The heads are small, short, symmetrical and spreading. The grain is long and slender, yellow in color. (Figure 57). These varieties mature in from 85 to 90 days.

Owing to their small heads and small slender kernels these early oats are not very attractive in appearance. However, in the majority of variety tests they have made a creditable showing in respect to yield.

MEDIUM EARLY VARIETIES OF OATS.

*Imported Scotch.* This is a medium early variety maturing in about 95 days. The straw is medium sized, averaging about 36 inches in height. It has a tendency to lodge on rich soil. The leaves are of medium width, dark green in color. The heads are of medium size, symmetrical and spreading. On the

[5]Nebraska Agr. Exp. Sta. Bulletin 84.

[6]U. S. Dept. of Agr., Bur. of Pl. Ind., Bulletin 66.

average the heads bear a relatively large number of spikelets in proportion to their length. The grain is long and slender but larger than the Kherson. The grain may be described as yellow in color but our strain throws a small percent of white grains.

### MEDIUM LATE VARIETIES WITH WHITE GRAIN AND SPREADING HEADS.

The great majority of oat varieties grown in this country belong to the medium oats with white grain and spreading heads. While there is some slight variation in the time of

*Fig. 57. Photograph showing the long slender type of grain characteristic of the Kherson variety. Compare with Fig. 58.*

maturity they all ripen under our conditions in from 95 to 100 days from the time of planting. On the basis of type of kernel these varieties may be still further subdivided in two groups. The distinction between these sub-groups is not very marked and for that reason was not included in the scheme of classifica-

tion given above. The first of these groups is characterized by medium sized but slender straight grains. The varieties Silver Mine, Early Pearl and Lincoln are typical of this group. These varieties all have medium coarse straw varying from 37 to 40 inches in height. The leaves are of medium width and vary from medium to dark green in color. The heads are medium sized, symmetrical and spreading. The varieties belonging to this group and which have been continued in these tests are Silver Mine, Irish Victor, Early Pearl, Lincoln, Minnesota No. 26, Prosperity and Danish Island. Of these the *Silver Mine* and *Irish Victor* have particularly slender grains. The straw of each is medium stiff with a slight tendency to lodge on rich soil. The Silver Mine averages 40 to 41 inches tall, while the Irish Victor varies from 37 to 39 inches under our conditions.

The *Lincoln* and *Prosperity* resemble each other in many respects. The Prosperity has slightly coarser straw and its grains are shorter and more plump.

*Minnesota No. 26.* This variety was originated at the Minnesota Experiment Station. It represents a selection from the variety known as the Early Gothland. The Minnesota No. 26 has been very widely grown in the middle west and has proved to be a good yielding variety.

This variety has medium coarse straw and is somewhat shorter than the other varieties in this group. It averages 36 to 37 inches in height. The grains are long and well filled, of a good white color.

*The Early Pearl.* This variety was secured from Mr. R. L. Copeland of Brewer, Maine, who writes of it as follows: "I can truthfully claim this oat originated with myself. The first seed was obtained from a bunch growing by the roadside some twenty years ago, presumably from one seed. It was examined and showed such merit that it was cut and preserved for seed. Although the first seed was not secured by me personally, it soon after came into my possession. The oat seemed to possess excellent qualities and as it matured fairly early and had a pearly tint to the hull, I gave it the name of Early Pearl. It must have always contained real merit for it is only in recent years that I have tried to improve it."

This variety breeds true and in all respects appears to be a pure line. It has stiff straw of medium size, averaging 38 to 40

inches in height. The leaves are medium in width, of a dark green color. The grain is long and plump.

The second sub-group of medium white oats is characterized by larger and more plump grains A typical variety is the Swedish Select. Other varieties belonging in this group are the Banner, Siberian, Abundance and President.

The *Swedish Select* has been a very popular variety in this country. It has rather weak, coarse straw, averaging 40 to 42 inches in height. Its leaves are of medium width and dark green in color. The grains are large and plump. The kernels are considerably shorter than the glumes giving the grain in many cases a peculiar notched appearance.

The *Regenerated Swedish Select* is the same oat to which the so-called regenerating process has been applied by the Garton-Cooper Seed Company. The method by which this regeneration is secured is to cross fertilize two plants of the same variety. The oat flower is normally always fertilized by its own pollen. That is, it is very closely inbred. If this self-fertilization is prevented and the flower fertilized with pollen from another plant it is claimed to produce a more vigorous strain. This variety shows the same characters as the Swedish Select except perhaps slightly larger grains.

The *Banner* and *Siberian* present practically the same characters. Both have stiff, medium coarse straw from 40 to 44 inches in height. The leaves are rather broad and dark green in color. The grains are plump, medium sized and well filled.

The *President* oat was introduced to the trade in 1908 by the Garton-Cooper Seed Company and was called "Garton's New Breed of White Oats"' It is claimed to be especially adapted to "hot, dry and otherwise unfavorable conditions." In our experience the straw is large and coarse, averaging 38 to 42 inches in height. The leaves are broad and dark green in color. The grains are very large and plump.

### MEDIUM LATE VARIETIES WITH YELLOW GRAIN.

The *Gold Rain* variety would belong to the first of the two sub-groups given above in respect to type of grain. However, its yellow color removes it to a different class. This oat was produced at Svalöf, Sweden, as a pedigreed selection from the

old Probstier variety. It has proved to be a very high yielder at Svalöf giving an average of over 100 bushels per acre in a nine year test.[1]

It has very stiff excellent straw, medium coarse and varies from 38 to 40 inches in height. The heads are symmetrical and spreading. The grain is long, fairly plump and yellow in color.

### MEDIUM LATE VARIETIES WITH BLACK GRAINS.

Two black grained varieties with open heads have been tested, but only one, the *Victor,* has been continued. In addition to its black grain, this oat possesses a number of peculiar characteristics. This oat was produced by the Garton-Cooper Seed Company. According to their description it was "bred from six different parents, two of which are fall oats." It has stiff medium coarse straw and grows very tall, averaging 46 to 59 inches. The leaves are broad and dark green in color. The heads are very long, symmetrical and very wide spreading with long drooping branches. The grain is very large and plump, similar in shape to the President but of a jet black color. This variety stools well. It is further peculiar in the manner of growth of the young plant. There is a very marked tendency for the young culms to spread out over the ground after the fashion of a true winter cereal.

### MEDIUM LATE VARIETIES WITH CLOSE SIDE HEAD.

Two varieties of typical side oats or so-called "Horse Mane Oats" are being continued in the variety tests.

The *Senator* is an exceptionally large grained oat. The straw is very coarse, averaging from 44 to 48 inches in height. The leaves are very broad, averaging about three-fourths of an inch in width and of a dark green color. The heads are very large, typical side heads. It is not uncommon to find heads with 100 to 140 spikelets. The variety stools very little and this undoubtedly accounts in part for its low yield under a system of uniform seeding. The grains are very large and plump (Fig. 58) and of a good white color. In this variety and pin oats are very often enclosed within the hull of the mother oat. On account of its large head and large grain this is a very attractive oat.

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[1]Newman, L. H. Plant Breeding in Scandinavia, p. 120, Ottawa, 1912.

The *White Plume* variety is listed here as a side oat although the particular strain which we have shows a few open heads every year. This is not such a large variety as the Senator. The straw is a little weaker, of medium size and from 36 to 40 inches tall. The grain is long and plump.

### MEDIUM LATE VARIETIES WITH INTERMEDIATE HEAD.

In 1913 a new variety was introduced from the Garton-Cooper Company known as *Garton No. 5*. The head of this oat is intermediate between an open head and a true side head. This oat originated, according to the Garton-Cooper Company,

*Fig. 58. Photograph of the Senator grain. The grains are very large and plump and the pin oat is usually enclosed in the glumes of the so-called "mother" oat. (Compare with Fig. 57.)*

from a cross between the Senator and the Regenerated Swedish Select. Its intermediate type of head, large grain and low stooling ability indicate its Senator parentage.

The straw of this variety is medium coarse, averaging about 40 inches in height. The leaves are broad and dark green in

color. The head has a node a few inches below the lower whorl as in typical side oats. The branches are stiff and remain nearly upright but the spikelets tend to fall to all sides of the main stem. The grains are very large and very plump, although they are not so large as those of the Senator. This variety stools very poorly.

### MEDIUM LATE VARIETIES OF MIXED TYPE.

Finally there is the variety purchased under the name of *American Clydesdale*. This variety is a mixture, about 50 percent are side oats, while the remainder have open heads. This mixture has yielded fairly well and for this reason has been retained in the tests. The straw is stiff, of medium size and 38 to 40 inches in height. The grains are long and fairly plump. The majority of the grains are white but a small percent are yellow. The seed which we are using is undoubtedly a mixture of several types.

### RESULTS OF THE 1910 VARIETY TEST.

Table 3 gives the detailed results of the 1910 test. In this table the varieties are arranged in the order of their yield of grain. In addition to the variety name there is given the number of the plot upon which it was grown and also the accession number which corresponds to the number given the varieties in Table 1. By means of these numbers it is possible to find the original source of the seed of any variety. The data given include the yield of straw and grain per 1-10 acre; the yield of grain calculated in bushels per acre[8]; the weight per measured bushel and the number of days which it took the variety to mature. It will be noted that in some cases several plots were planted with the same variety. In these cases the seed for each plot came from different sources (cf. Table 1).

All of the plots were planted on May 5 and 6. Plots Nos. 6, 7 and 9 were harvested on July 29, plot No. 23 on August 5, and the remaining plots on August 9.

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[8]This refers to bushels by weight, allowing 32 pounds to the bushel.

## TABLE 3.

*Variety Test in 1910.*

| Accession number* | Name of Variety. | Plot number. | Yield per 1-10 Acre. Straw, Pounds. | Yield per 1-10 Acre. Grain, Pounds. | Bushels. Per acre. | Weight per measured bushel. | Number of days to mature. |
|---|---|---|---|---|---|---|---|
| 15 | Regenerated Swedish Select | 15 | 280.0 | 234.5 | 73.3 | 41.0 | 95 |
| 13 | Regenerated Swedish Select | 13 | 284.3 | 230.7 | 72.1 | 44.0 | 95 |
| 11 | Silver Mine | 11 | 278.0 | 227.0 | 71.0 | 39.4 | 95 |
| 26 | Banner | 26 | 248.5 | 226.5 | 70.8 | 39.7 | 96 |
| 8 | Irish Victor | 8 | 312.0† | 225.5 | 70.5 | 37.9 | 95 |
| 12 | Lincoln | 12 | 299.0 | 224.0 | 70.0 | 40.0 | 95 |
| 14 | Regenerated Swedish Select | 14 | 279.5 | 222.5 | 69.5 | 41.3 | 95 |
| 6 | Kherson (Univ.) | 6 | 250.3 | 222.3 | 69.4 | 30.2 | 84 |
| 28 | Banner | 28 | 253.5 | 221.5 | 69.2 | – | 96 |
| 17 | President | 17 | 261.7 | 218.3 | 68.2 | 40.0 | 95 |
| 4 | Tartar King | 4 | 297.5 | 215.5 | 67.3 | – | 95 |
| 22 | Newmarket | 22 | 254.0 | 213.5 | 66.7 | – | 96 |
| 30 | Ligowo | 30 | 277.5 | 212.5 | 66.4 | – | 96 |
| 5 | Black Tartarian | 5 | 263.5 | 211.5 | 66.1 | – | 95 |
| 9 | Early Champion | 9 | 264.5 | 211.5 | 66.1 | 42.8 | 84 |
| 31 | Maine Grown (Hamlin) | 31 | 242.7 | 210.3 | 65.7 | – | 96 |
| 16 | Swedish Select | 16 | 245.3 | 209.7 | 65.5 | – | 95 |
| 10 | Prosperity | 10 | 287.5 | 209.5 | 65.5 | 38.9 | 95 |
| 27 | Banner | 27 | 254.5 | 208.0 | 65.0 | – | 96 |
| 29 | Banner | 29 | 245.3 | 206.7 | 64.6 | – | 96 |
| 7 | Kherson | 7 | 234.0 | 203.5 | 63.6 | 33.8 | 84 |
| 25 | Maine Grown | 25 | 222.3 | 193.3 | 60.4 | – | 96 |
| 23 | Imported Scotch | 23 | 243 0 | 192.0 | 60.0 | 34.8 | 91 |
| 19 | Victor | 19 | 261.5 | 190.5 | 59.5 | 41.6 | 95 |
| 3 | White Tartar King | 3 | 260.7 | 185.3 | 57.9 | – | 95 |
| 2 | Burpee's Welcome | 2 | 231.7 | 181.3 | 56.6 | – | 95 |
| 21 | White Egyptian | 21 | 289.7 | 181.3 | 56.6 | – | 96 |
| 24 | Early Blossom | 24 | 286.3 | 178.7 | 55.8 | – | 96 |
| 20 | Old Island Black | 20 | 244.5 | 178.0 | 55.6 | – | 96 |
| 18 | Senator | 18 | 248.7 | 171.2 | 53.5 | 40.8 | 95 |
| 1 | Danish Island | 1 | 235.3 | 149.2 | 46.7 | 37.0 | 95 |
| | Average | | 262.5 | 205.4 | 64.2 | 39.0 | 94 |

*The "accession number" in this and the following tables refer to the arbitrary numbers given to the varieties in Table 1 (p. 149). By means of these numbers it is possible to find the original source of the seed of any variety.

†Straw damp when weighed.

From Table 3 it will be noted:

1. That the yield of grain varied from 73.3 to 46.7 bushels per acre. The average for all the varieties was 64.2 bushels.

2. The Regenerated Swedish Select (Nos. 15 and 13) gave the highest yield. The third sample of Regenerated Swedish Select (No. 14) yielded very nearly as well (69.5 bushels).

3. The varieties Silver Mine, Banner (Nos. 26 and 28), Irish Victor, Lincoln, Kherson (No. 6) and President all gave very good yields.

4. Of the four lots of Banner Oats the two (Nos. 26 and 28) which came from Alberta and Saskatchewan, Canada,

yielded much better than Nos. 27 and 29 which came from Ontario and New Brunswick.

5. The yield of straw varied from about 3000 to 2200 pounds per acre. The average for all the varieties was 2625 pounds per acre.

6. The weight per measured bushel is given for the varieties which were continued in 1911. The weights varied from 44.0 pounds in the Regenerated Swedish Select (No. 13) to 30.2 pounds in the Kherson (No. 6). The average for all sixteen varieties is 39.0 pounds per bushel.

7. The Kherson and Early Champion plots matured in 84 days, the Imported Scotch in 91 days and the remaining varieties in 95 to 96 days.

### RESULTS OF THE 1911 TESTS.

Seventeen varieties were tested in 1911. With the exception of the American Clydesdale (No. 32) the seed was derived from our 1910 plots. In general only those varieties were continued which showed special promise in the 1910 test or which showed special characters which it was wished to study further. In many respects the 1911 test was very unsatisfactory. The early portion of the season was very unfavorable. Certain difficulties were experienced in seeding so that the plots did not have an even stand in all cases. Further it appears that the grain was harvested too early and was probably not fully matured. It will be noted from Table 4 that the average number of days to mature for all varieties was only 88 in 1911, while in the other years it ranged from 94 to 101. All of the plots were planted May 9 and 10.

Table 4 gives the detailed results of this test. In the following discussion the points mentioned in the above paragraph should be borne in mind.

TABLE 4.

*Variety Test in 1911.*

| Accession number. | Name of Variety. | Plot number. | Yield per 1-10 Acre. | | Bushels per acre. | Weight per measured bushel. | Date harvested. | Number of days to mature. |
|---|---|---|---|---|---|---|---|---|
| | | | Straw. Pounds. | Grain. Pounds. | | | | |
| 23 | Imported Scotch | 55 | 260.3 | 199.7 | 62.4 | 36.4 | Aug. 4 | 86 |
| 8 | Irish Victor | 46 | 279.5 | 178.0 | 55.6 | 36.9 | Aug. 1 | 83 |
| 32 | American Clydesdale | 43 | 249.0 | 176.0 | 55.0 | 39.3 | Aug. 5 | 88 |
| 19 | Victor | 54 | 245.5 | 174.5 | 54.5 | 41.7 | Aug. 14 | 96 |
| 11 | Silver Mine | 49 | 237.0 | 173.0 | 54.0 | 39.8 | Aug. 4 | 86 |
| 10 | Prosperity | 48 | 286.0 | 169.0 | 52.8 | 39.2 | Aug. 1 | 83 |
| 7 | Kherson | 57 | 225.0 | 160.0 | 50.0 | 34.2 | July 27 | 78 |
| 17 | President | 52 | 261.5 | 158.5 | 49.5 | 41.6 | Aug. 5 | 87 |
| 6 | Kherson | 45 | 297.0 | 153.0 | 47.8 | 33.1 | July 26 | 77 |
| 12 | Lincoln | 50 | 242.5 | 152.5 | 47.7 | 40.0 | Aug. 14 | 96 |
| 1 | Danish Island | 44 | 198.0 | 152.0 | 47.5 | 39.0 | Aug. 8 | 90 |
| 26 | Banner | 56 | 335.0 | 146.5 | 45.8 | 39.8 | Aug. 14 | 96 |
| 14 | Regenerated Swedish Select. | 58 | 360.0 | 139.5 | 43.6 | 42.6 | Aug. 14 | 96 |
| 13 | Regenerated Swedish Select. | 51 | 219.0 | 131.0 | 40.9 | 42.8 | Aug. 14 | 96 |
| 9 | Early Champion | 47 | 299.7 | 125.3 | 39.1 | 38.6 | July 22 | 73 |
| 18 | Senator | 53 | 297.5 | 122.5 | 38.3 | 41.5 | Aug. 14 | 96 |
| 15 | Regenerated Swedish Select. | 59 | 273.0 | 122.0 | 36.7 | 39.5 | Aug. 8 | 90 |
| | Average | | 268.8 | 154.9 | 48.3 | 39.2 | | 88 |

From Table 4 the following points may be noted:

1. The yield in bushels per acre ranged from 62.4 to 36.7. The average for the seventeen varieties was 48.3 bushels. This was nearly 16 bushels less than the average for 1910.

2. The Imported Scotch far outyielded any other variety. The varieties which came next in point of yield were the Irish Victor, American Clydesdale, Victor, Silver Mine and Prosperity.

3. The Kherson (Nos. 6 and 7), President, Lincoln, Danish Island and Banner (No. 26) yielded at intermediate rates.

4. It is of interest to note that the three strains of Regenerated Swedish Select which yielded so well in 1910 were very poor yielders in 1911. Curiously enough the Regenerated Swedish Select No. 15 which was the best yielder in 1910 was the very poorest in 1911. This strain yielded only half as many bushels per acre in 1911 as in the previous year.

5. The yield of straw varied from 3600 pounds to 1980 pounds per acre. The average for all varieties was 2688 pounds, practically the same as in the previous year.

6. The weight per measured bushel varied from 42.8 pounds in the case of the Regenerated Swedish Select (No. 13) to 33.1

pounds in the Kherson (No. 6). The average for all varieties was 39.2 pounds, practically the same as the weight for the same varieties (excepting American Clydesdale) in 1910.

7. Attention has already been called to the fact that the average number of days to maturity was much smaller in 1911 than in any other year. This probably accounts in part for the small yield.

## Results of the 1912 Test.

In 1912 eight new varieties were introduced. These were the White Plume, Rebred 60-Day, Daubeney, Siberian, Abundance, Gold Rain, Minnesota No. 26 and the Early Pearl. In addition to these, the thirteen different varieties grown in 1911 were continued. However, only one strain of the Regenerated Swedish Select and one of the Kherson were continued.

It has already been stated that in 1912 each variety was planted in duplicate 1-10 acre plots. In each case the two plots of a variety were in different fields (Cf. Fig. 53). It has further been noted that field A was very poorly drained and consequently could not be planted until nearly three weeks after field B. In nearly every instance the yield in the late seeded plot was lower than the duplicate plot in field B. In the case of four varieties, viz., Gold Rain, Siberian, Abundance, and Daubeney both plots were planted late. This was due to the wet condition of the soil at one place in field B. No doubt the average yield of these varieties is somewhat less than if the one plot had been seeded early.

Table 5 gives the results of the 1912 test. In this table the detailed results of each plot are given separately, together with the average for the two plots of each variety. The varieties are arranged in the order of the average yield of grain from the two plots.

## TABLE 5.

### *Variety Test in 1912.*

| Accession number. | Name of Variety. | Plot number. | Yield per 1-10 Acre. Straw. Pounds. | Yield per 1-10 Acre. Grain. Pounds. | Bushels per acre. | Weight per measured bushel. | Date harvested. | Days to maturity. |
|---|---|---|---|---|---|---|---|---|
| 12 | Lincoln | 181 | 254.0 | 226.0 | 70.6 | 39.7 | Aug. 16* | 104 |
| | | 182 | 334.3 | 210.7 | 65.9 | 33.2 | Aug. 31 | 100 |
| | *Average* | | *294.2* | *218.4* | *68.3* | *36.5* | | |
| 10 | Prosperity | 177 | 281.0 | 234.0 | 73.1 | 39.2 | Aug. 16* | 104 |
| | | 178 | 257 5 | 197.5 | 61.7 | 35.5 | Aug. 31 | 100 |
| | *Average* | | *269.3* | *215.8* | *67.4* | *37.4* | | |
| 40 | Early Pearl | 199 | 286.5 | 243.5 | 76.1 | 37.7 | Aug. 16* | 104 |
| | | 200 | 173.0 | 167.0 | 52.2 | 33.3 | Aug. 31 | 100 |
| | *Average* | | *229.8* | *205.3* | *64.2* | *35.5* | | |
| 26 | Banner | 193 | 249.5 | 225.5 | 70.5 | 37.7 | Aug. 16* | 104 |
| | | 194 | 265.0 | 175.0 | 54.7 | 33.0 | Aug. 31 | 100 |
| | *Average* | | *257.3* | *200.3* | *62.6* | *35.4* | | |
| 23 | Imported Scotch | 191 | 157.3 | 202.7 | 63 3 | 36.7 | Aug. 16* | 104 |
| | | 192 | 259.7 | 195.3 | 61.0 | 32.6 | Aug. 31 | 100 |
| | *Average* | | *208.5* | *199.0* | *62.2* | *34.7* | | |
| 8 | Irish Victor | 173 | 216.3 | 198.7 | 62.1 | 39.0 | Aug. 16* | 104 |
| | | 174 | 234.5 | 195.5 | 61.1 | 34.9 | Aug. 31 | 100 |
| | *Average* | | *225.4* | *197.1* | *61.6* | *37.0* | | |
| 17 | President | 185 | 363 0 | 222.0 | 69.4 | 37.3 | Aug. 13* | 101 |
| | | 186 | 273.5 | 171.5 | 53.5 | 34.2 | Aug. 31 | 100 |
| | *Average* | | *318.3* | *196.8* | *61.5* | *35.8* | | |
| 1 | Danish Island | 169 | 264.0 | 196.0 | 61.3 | 38.4 | Aug. 16* | 104 |
| | | 170 | 192.0 | 173.0 | 54.1 | 33.0 | Aug. 31 | 100 |
| | *Average* | | *228.0* | *184.5* | *57.7* | *35.7* | | |
| 19 | Victor | 189 | 314.0 | 221.0 | 69.1 | 42.9 | Aug. 13* | 101 |
| | | 190 | 220.5 | 142.8 | 44.6 | 38.3 | Aug. 31 | 100 |
| | *Average* | | *267.3* | *181.9* | *56.9* | *40.6* | | |
| 13 | Regenerated Swedish Select. | 183 | 420.0 | 178.0 | 55.6 | 43.3 | Aug. 13* | 101 |
| | | 184 | 214.7 | 183.3 | 57.3 | 35.3 | Aug. 31 | 100 |
| | *Average* | | *330.8* | *180.7* | *56.5* | *39.3* | | |
| 32 | American Clydesdale | 167 | 394.0 | 206.0 | 64 4 | 39.3 | Aug. 12* | 100 |
| | | 168 | 172.5 | 142.5 | 44.5 | 34.2 | Aug. 31 | 100 |
| | *Average* | | *283.3* | *174.3* | *54.5* | *36.8* | | |
| 38 | Gold Rain | 203 | 222.0 | 163.0 | 50.9 | 36.4 | Aug. 31 | 100 |
| | | 204 | 244.0 | 181.0 | 56.6 | 37.6 | Aug. 31 | 100 |
| | *Average* | | *233.0* | *172.0* | *53.8* | *37.0* | | |
| 18 | Senator | 187 | 273.5 | 196.5 | 61.4 | 37.2 | Aug. 16* | 104 |
| | | 188 | 238.9 | 145.8 | 45.6 | 33.1 | Aug. 31 | 100 |
| | *Average* | | *256.7* | *171.2* | *53.5* | *35.2* | | |
| 11 | Silver Mine | 179 | 452.0 | 145.0 | 45.3 | 42.2 | Aug. 13* | 101 |
| | | 180 | 223.6 | 193.7 | 60.5 | 36.2 | Aug. 31 | 100 |
| | *Average* | | *337.8* | *169.4* | *52.9* | *39.2* | | |
| 39 | Minnesota No. 26 | 207 | 219.7 | 150.3 | 47.0 | 38.3 | Aug. 31 | 100 |
| | | 208 | 188.5 | 186.5 | 58.3 | 37.5 | Aug. 31 | 100 |
| | *Average* | | *204.1* | *168.4* | *52.7* | *37.9* | | |
| 6 | Kherson | 171 | 202.3 | 164.7 | 51.5 | 35.3 | Aug. 5* | 93 |
| | | 172 | 163.0 | 172.0 | 53.8 | 35.4 | Aug. 21 | 90 |
| | *Average* | | *182.6* | *168.4* | *52.7* | *35.4* | | |

TABLE 5—Concluded.

| Accession number. | Name of Variety. | Plot number. | Yield per 1-10 Acre. Straw. Pounds. | Yield per 1-10 Acre. Grain. Pounds. | Bushels per acre. | Weight per measured bushel | Date harvested. | Days to maturity. |
|---|---|---|---|---|---|---|---|---|
| 9 | Early Champion | 175 | 248.0 | 187.0 | 58.4 | 35.3 | Aug. 5* | 93 |
| | | 176 | 194.5 | 135.5 | 42.3 | 35.2 | Aug. 16 | 85 |
| | *Average* | | *221.3* | *161.3* | *50.4* | *35.2* | | |
| 36 | Siberian | 205 | 246.3 | 148.7 | 46.5 | 30.6 | Sept. 5 | 105 |
| | | 206 | 284.0 | 171.0 | 53.4 | 31.2 | Sept. 4 | 104 |
| | *Average* | | *265.2* | *159.9* | *50.0* | *30.9* | | |
| 37 | Abundance | 209 | 209.7 | 155.0 | 48.5 | 34.5 | Sept. 5 | 105 |
| | | 210 | 173.5 | 151.5 | 47.3 | 35.0 | Aug. 31 | 100 |
| | *Average* | | *191.6* | *153.3* | *47.9* | *34.8* | | |
| 34 | Rebred 60-Day | 197 | 135.0 | 163.0 | 50.9 | 32.5 | Aug. 5* | 93 |
| | | 198 | 149.0 | 141.0 | 44.1 | 34.3 | Aug. 21 | 90 |
| | *Average* | | *142.0* | *152.0* | *47.5* | *33.4* | | |
| 33 | White Plume | 195 | 190.0 | 170.0 | 53.1 | 38.1 | Aug. 16* | 100 |
| | | 196 | 168.0 | 112.0 | 35.0 | 30.0 | Aug. 31 | 100 |
| | *Average* | | *179.0* | *141.0* | *44.0* | *34.1* | | |
| 35 | Daubeney | 201 | 171.0 | 139.0 | 43.4 | 36.3 | Aug. 21 | 90 |
| | | 202 | 142.0 | 138.0 | 43.1 | 37.0 | Aug. 21 | 90 |
| | *Average* | | *156.5* | *138.5* | *43.3* | *36.7* | | |
| | *Average of plots planted May 4* | – | *276.5* | *198.8* | *62.1* | *38.5* | – | 101 |
| | *Average of plots planted May 23* | – | *217.1* | *164.2* | *51.4* | *34.7* | – | 98 |
| | *Average of all plots* | – | *240.1* | *177.7* | *55.6* | *36.1* | – | 99 |

*Plots marked with (*) were planted May 4, the remaining plots were planted May 23.

From this table the following points may be noted:

1. The average yield for the two plots ranges from 68.3 bushels per acre in the case of the Lincoln variety to 43.3 bushels in the Daubeney. The average yield of all the plots is 55.6 bushels per acre. The average yield of the early seeded plots in field B is 62.1 bushels, while the average of the late seeded plots is only 51.4 bushels. This decrease in yield of 10.7 bushels or nearly 18 percent is due mainly to the late seeding.

2. The highest yield of any plot in field B was at the rate of 76.1 bushels per acre for the Early Pearl variety. Three other plots in this field yielded above 70 bushels per acre. The highest yield in field A was from the Lincoln plot which yielded at the rate of 65.9 bushels per acre. Only four other plots in this field yielded more than 60 bushels per acre.

3. Of the 10 varieties ranking highest in point of yield, nine were varieties which had been tested in the two preceding years. Only one of the varieties introduced in this year, the Early Pearl, ranked among the first 10.

4. The Imported Scotch which yielded best in 1911 ranked fifth in point of yield in 1912. The Regenerated Swedish Select which was one of the best yielding varieties in 1910, but very poor in 1911, ranked tenth in yield in this year. The Senator which yielded poorly in the two preceding seasons gave an average yield in 1912. The Senator plot in field B yielded very well. The Silver Mine which had yielded well in the two previous years gave only an average yield in this year. It is to be noted that the late seeded plot of this variety yielded best. This was also true of a few other varieties.

5. The average yield of straw for all plots was 2401 pounds per acre. This is slightly less than the average for the preceding year. The early seeded plots gave 2765 pounds per acre, while the late seeded plots gave only 2171 pounds.

6. The average weight per measured bushel for all plots was 36.1 pounds. This is about three pounds less than for either of the previous years. The fact that a number of new varieties were grown this year may in some measure account for this decrease. It will further be noted that the grain from the early seeded plots average to weigh nearly four pounds more per bushel than grain from the late seeded plots.

7. The average number of days from planting to harvesting was 99.5 days.

## Results of the 1913 Test.

It has already been stated that in 1913 different methods were adopted in the variety test work. The chief difference was in the use of four small plots (1-40 acre) in place of a single, or as in 1912 duplicate, 1-10 acre plots. The four plots of any one variety were scattered through the field so that on the average the four plots of any variety were more likely to encounter average soil conditions than if they were in a single large plot. Each 1-40 acre plot was in the shape of a square, each side being 33 feet long. It has been shown by one of the writers[9] that this

[9]Barber, C. W. *Loc. cit.*

is the most desirable shape for a small plot. The field containing these plots was slightly irregular in shape but with the exception of four plots all of these plots were in five tiers. Four of these tiers contained 17 plots each, while the fifth tier had only 12 plots. It will thus be seen that all the plots were arranged in a compact group.

In table 6 there are given the detailed data relative to each plot, together with the averages for all four plots of each variety. The varieties are arranged in the order of their average production of grain. The yield of straw is given both for the 1-40 acre and also the calculated yield per acre. These latter figures are easily compared with the yields for the 1-10 acre plots given for the previous years.

It should be said that each 1-40 acre plot was remeasured before harvesting. In a few plots the actual area varied slightly from 1-40 acre. The plots in Table 6 which are marked with an * have had the actual yield calculated to the base of 1-40 acre so as to be directly comparable with the remaining plots.

All of the plots were planted on May 5, 6 and 7. The Kherson and Rebred 60-Day plots were harvested July 31 to Aug. 2. The Daubeney plots were harvested between July 31 and Aug. 7. The remaining varieties were harvested between Aug. 11 and 20.

In all, 21 commercial varieties were tested in 1913. Two varieties, The Danish Island and Early Champion, which had been tested in the three preceding years, were dropped from the test. One new variety, viz., Garton No. 5, was added in this year.

## TABLE 6.

### *Variety Test in 1913.*

| Accession number. | Name of Variety. | Plot number. | Straw Yield. | | Grain Yield. | | Weight per measured bushel. | Days to maturity. |
|---|---|---|---|---|---|---|---|---|
| | | | Lbs. per plot. | Lbs. per acre. | Lbs. per 1-40 acre plot. | Bu. per acre. | | |
| 36 | Siberian | 477 | 98.5 | 3940 | 60.5 | 75.6 | – | 105 |
| | | 498 | 81.5 | 3260 | 50.5 | 63.1 | 35.0 | 104 |
| | | 519 | 80.0 | 3200 | 55.0 | 68.8 | 34.9 | 105 |
| | | 540 | 87.5 | 3500 | 61.5 | 76.9 | 34.0 | 105 |
| | *Average* | | *86.9* | *3475* | *56.9* | *71.1* | *34.7* | *105* |
| 40 | Early Pearl | 474 | 71.0 | 2840 | 54.0 | 67.5 | 33.3 | 105 |
| | | 495 | 101.5 | 4060 | 67.5 | 84.4 | 32.8 | 103 |
| | | 516 | 59.0 | 2360 | 51.0 | 63.7 | – | 10 |
| | | 537 | 66.5 | 2660 | 50.5 | 63.1 | 33.9 | 104 |
| | *Average* | | *74.5* | *2980* | *55.8* | *69.7* | *33.3* | *103* |
| 39 | Minnesota No. 26 | 478 | 81.5 | 3260 | 53.5 | 66.9 | 35.1 | 105 |
| | | 499 | 73.5 | 2940 | 58.5 | 73.1 | 36.6 | 104 |
| | | 520 | 53.5 | 2140 | 48.5 | 60.6 | 36.8 | 98 |
| | | 541 | 84.7 | 3388 | 56.3 | 70.3 | 36.0 | 105 |
| | *Average* | | *73.3* | *2932* | *54.2* | *67.7* | *36.1* | *103* |
| 23 | Imported Scotch | 470 | 65.5 | 2620 | 55.5 | 69.4 | 35.8 | 100 |
| | | 491 | 64.5 | 2580 | 52.5 | 65.6 | 35.2 | 100 |
| | | 512 | 54.0 | 2160 | 52.0 | 65.0 | – | 99 |
| | | 533 | 79.5 | 3180 | 56.5 | 70.6 | 33.6 | 105 |
| | *Average* | | *65.9* | *2635* | *54.1* | *67.7* | *34.9* | *101* |
| 8 | Irish Victor | 462 | 64.0 | 2560 | 50.0 | 62.5 | 36.6 | 101 |
| | | 483 | 77.0 | 3080 | 58.0 | 72.5 | 35.5 | 105 |
| | | 504 | 82.5 | 3300 | 52.5 | 65.6 | – | 102 |
| | | 525 | 77.0 | 3080 | 54.0 | 67.5 | 36.0 | 97 |
| | *Average* | | *75.1* | *3005* | *53.6* | *67.0* | *36.1* | *101* |
| 12 | Lincoln | 465 | 94.0 | 3760 | 57.0 | 71.3 | 33.1 | 107 |
| | | 486 | 84.5 | 3380 | 52.5 | 65.6 | – | 107 |
| | | 507 | 71.5 | 2860 | 51.5 | 64.4 | – | 105 |
| | | 528 | 66.0 | 2640 | 50.0 | 62.5 | 33.6 | 105 |
| | *Average* | | *79.0* | *3160* | *52.8* | *65.9* | *33.3* | *106* |
| 38 | Gold Rain | 476 | 92.5 | 3700 | 60.5 | 75.6 | 36.7 | 107 |
| | | 497 | 66.5 | 2660 | 39.5 | 49.4 | – | 105 |
| | | 518 | 75.0 | 3000 | 54.0 | 67.5 | – | 105 |
| | | 539 | 70.5 | 2820 | 54.5 | 68.1 | 36.2 | 104 |
| | *Average* | | *76.1* | *3045* | *52.1* | *65.2* | *36.4* | *105* |
| 37 | Abundance | 479 | 72.5 | 2900 | 53.5 | 66.9 | 35.4 | 106 |
| | | 500 | 54.0 | 2160 | 47.0 | 58.8 | 39.0 | 97 |
| | | 521 | 71.0 | 2840 | 51.0 | 63.7 | 36.8 | 102 |
| | | 542 | 85.0 | 3400 | 54.0 | 67.5 | 36.3 | 105 |
| | *Average* | | *70.6* | *2825* | *51.4* | *64.2* | *36.8* | *103* |
| 33 | White Plume | 472 | 57.5 | 2300 | 49.5 | 61.9 | 37.3 | 99 |
| | | 493 | 71.0 | 2840 | 49.0 | 61.3 | 35.2 | 103 |
| | | 514 | 68.0 | 2720 | 43.0 | 53.7 | 36.8 | 97 |
| | | 535 | 83.5 | 3340 | 61.5 | 76.9 | 35.4 | 104 |
| | *Average* | | *70.0* | *2800* | *50.8* | *63.4* | *36.2* | *101* |
| 10 | Prosperity | 463 | 66.0 | 2640 | 50.0 | 62.5 | 35.8 | 103 |
| | | 484 | 80.0 | 3200 | 57.0 | 71.3 | 35.6 | 103 |
| | | 505 | 52.5 | 2100 | 47.5 | 59.4 | 40.3 | 97 |
| | | 526 | 65.0 | 2600 | 47.0 | 58.7 | 34.9 | 105 |
| | *Average* | | *65.9* | *2635* | *50.4* | *63.0* | *36.7* | *102* |
| 7 | President | 467 | 67.5 | 2700 | 58.5 | 73.1 | 35.6 | 105 |
| | | 488 | 69.0 | 2760 | 49.0 | 61.3 | – | 106 |
| | | 509 | 54.5 | 2180 | 45.5 | 56.9 | – | 104 |
| | | 530 | 56.5 | 2260 | 48.5 | 60.6 | 36.0 | 105 |
| | *Average* | | *61.9* | *2475* | *50.4* | *63.0* | *35.8* | *105* |

## Table 6—Concluded.

| Accession number. | Name of Variety. | Plot number. | Straw Yield. Lbs. per plot. | Straw Yield. Lbs. per acre. | Grain Yield. Lbs. per 1-40 acre plot. | Grain Yield. Bu. per acre. | Weight per measured bushel. | Days to maturity. |
|---|---|---|---|---|---|---|---|---|
| 32 | American Clydesdale | 460 | 81.5 | 3260 | 53.5 | 66.9 | 33.9 | 105 |
| | | 481 | 55.0 | 2200 | 45.0 | 56.3 | 36.5 | 101 |
| | | *502 | 76.9 | 3077 | 49.8 | 62.2 | 36.5 | 104 |
| | | 523 | 74.5 | 2980 | 52.5 | 65.6 | 34.6 | 102 |
| | *Average* | | *72.0* | *2879* | *50.2* | *62.8* | *35.4* | *103* |
| 26 | Banner | 471 | 88.5 | 3540 | 55.5 | 69.4 | 33.9 | 107 |
| | | 492 | 66.0 | 2640 | 44.0 | 55.0 | - | 106 |
| | | 513 | 54.0 | 2160 | 44.0 | 55.0 | - | 104 |
| | | 534 | 78.7 | 3148 | 57.3 | 71.6 | 34.8 | 105 |
| | *Average* | | *71.8* | *2872* | *50.2* | *62.7* | *34.3* | *106* |
| 13 | Regenerated Swedish Select | 466 | 72.0 | 2880 | 49.0 | 61.2 | 34.2 | 105 |
| | | *487 | 61.8 | 2472 | 49.2 | 61.6 | 34.6 | 106 |
| | | *508 | 51.1 | 2042 | 42.3 | 52.9 | - | 105 |
| | | *529 | 82.5 | 3300 | 54.4 | 68.0 | 36.4 | 106 |
| | *Average* | | *66.9* | *2674* | *48.7* | *60.9* | *35.1* | *106* |
| 6 | Kherson | 461 | 64.0 | 2560 | 53.0 | 66.3 | 35.6 | 89 |
| | | 482 | 60.5 | 2420 | 48.5 | 60.6 | - | 87 |
| | | 503 | 63.5 | 2540 | 44.5 | 55.6 | 36.9 | 87 |
| | | 524 | 70.5 | 2820 | 48.5 | 60.6 | - | 87 |
| | *Average* | | *64.6* | *2585* | *48.6* | *60.8* | *36.2* | *88* |
| 19 | Victor | 469 | 68.0 | 2720 | 46.0 | 57.5 | 35.2 | 105 |
| | | 490 | 78.0 | 3120 | 55.0 | 68.7 | 36.8 | 106 |
| | | 511 | 52.0 | 2080 | 40.0 | 50.0 | 39.7 | 99 |
| | | 532 | 73.5 | 2940 | 49.5 | 61.9 | 35.7 | 101 |
| | *Average* | | *67.9* | *2715* | *47.6* | *59.5* | *36.8* | *103* |
| 11 | Silver Mine | 464 | 56.0 | 2240 | 48.0 | 60.0 | 36.5 | 103 |
| | | 485 | 50.0 | 2000 | 42.0 | 52.5 | - | 102 |
| | | 506 | 73.0 | 2920 | 50.0 | 62.5 | 37.1 | 106 |
| | | 527 | 52.0 | 2080 | 45.0 | 56.3 | - | 101 |
| | *Average* | | *57.8* | *2310* | *46.3* | *57.8* | *36.8* | *103* |
| 34 | Rebred 60-Day | 473 | 35.5 | 1420 | 35.5 | 44.4 | 36.2 | 87 |
| | | 494 | 62.5 | 2500 | 56.5 | 70.6 | 35.1 | 88 |
| | | 515 | 41.0 | 1640 | 39.0 | 48.8 | 36.4 | 86 |
| | | 536 | 49.0 | 1960 | 43.0 | 53.7 | 36.2 | 85 |
| | *Average* | | *47.0* | *1880* | *43.5* | *54.4* | *35.9* | *87* |
| 35 | Daubeney | 475 | 76.5 | 3060 | 56.0 | 70.0 | 34.4 | 98 |
| | | 496 | 40.5 | 1620 | 36.5 | 45.6 | - | 86 |
| | | 517 | 54.5 | 2180 | 35.5 | 44.4 | - | 86 |
| | | 538 | 71.0 | 2840 | 39.0 | 48.7 | 37.8 | 92 |
| | *Average* | | *60.6* | *2425* | *41.8* | *52.2* | *36.1* | *91* |
| 18 | Senator | 468 | 68.5 | 2740 | 50.5 | 63.1 | 30.7 | 105 |
| | | 489 | 75.0 | 3000 | 51.0 | 63.7 | 34.0 | 105 |
| | | 510 | 44.5 | 1780 | 37.5 | 46.9 | - | 97 |
| | | 531 | 80.5 | 3220 | 26.5 | 33.1 | - | 105 |
| | *Average* | | *67.1* | *2685* | *41.4* | *51.7* | *32.4* | *103* |
| 41 | Garton No. 5 | *480 | 87.8 | 3510 | 48.6 | 60.8 | 31.5 | 106 |
| | | 501 | 49.3 | 1972 | 32.7 | 40.9 | - | 93 |
| | | 522 | 73.0 | 2920 | 30.0 | 48.7 | - | 105 |
| | | 543 | 70.5 | 2820 | 44.5 | 55.6 | - | 104 |
| | *Average* | | *70.1* | *2806* | *41.2* | *51.5* | *31.5* | *102* |
| | *Average all varieties* | | *68.8* | *2751* | *49.6* | *62.0* | *35.5* | *101* |

*Size of plots varied from 1-42 to 1-50 acre. Yields of these calculated to 1-40 acre basis.

The following points are brought out in Table 6:

1. The average yield of the four plots of the several varieties ranged from 71.1 bushels per acre in the Siberian to 51.5 bushels in the Garton No. 5. This is a range of about 20 bushels between the best and the poorest variety. This range is some 5 to 7 bushels less than in any of the preceding years. This is no doubt due, in a large measure, to the fact that these are averages of four plots rather than the yield of a single plot.

2. The highest yielding single plot was the Early Pearl Plot No. 495 which yielded at the rate of 84.4 bushels per acre. The lowest yielding single plot was the Garton No. 5 (plot 501) which gave 40.9 bushels per acre. The difference between the highest and lowest single plot is 43.9 bushels.

3. The average yield for all the varieties was 62 bushels per acre. This is a better average production than in any of the preceding years except 1910. This comparison is hardly fair, however, since the varieties tested in different years were not all the same. The yield of those varieties which have been tested for all four years will be discussed in a later paragraph (Cf. p. 175).

4. Of the ten highest yielding varieties in 1913, six were varieties introduced in 1912. It will be remembered that in the discussion of Table 5 it was pointed out that only one variety, the Early Pearl, introduced in 1912, was among the ten best producers of that year. It is probable that this result is in part due to acclimatization. It will be remembered that the Early Pearl variety was originated in Maine. The other varieties imported in 1912 were from Canada and the Middle West. They did very poorly the first year but very much better the second. This point is also discussed on page 177.

5. The four out of the ten best yielding varieties which were introduced before 1912 are in order, the Imported Scotch, Irish Victor, Lincoln and Prosperity. It will be shown later (Fig. 59) that these are the four best yielding varieties on a four year average.

6. The Siberian which yielded best in 1913 was a very poor producer in 1912, yielding only 50 bushels per acre. The Early Pearl, on the other hand, yielded very well in 1913, standing third in order of productiveness. The Senator which yielded very poorly in 1910 and 1911 is again at the bottom of the list in

1913. Also the Silver Mine which yielded relatively very well in 1910 and 1911 yielded relatively very poorly in both 1912 and 1913.

7. The average yield of straw per acre varied from 3475 pounds in the Siberian to 1880 pounds in the Rebred 60-Day. The average yield of straw for all varieties is 2751 pounds per acre. This is a slightly higher average yield than in the preceding years.

8. The average weight per measured bushel for all varieties was only 35.5 pounds. This is considerably lower than in the previous years, especially 1910 and 1911. This will be discussed more in detail at another place (cf. p. 186).

9. The average length of time from planting to harvesting was 101 days, a slightly longer average growing period than in the other years.

### VARIATION IN THE YIELD OF THE 1913 PLOTS.

The use of four plots of each variety situated in different parts of the same field gives an opportunity to study the effect of the environment on each variety. The seed for each of the four plots of any variety was all taken from the same bag. For all practical purposes the seed for any set of four plots may be regarded as identical. The differences in the yield of the plots of any variety may, therefore, be attributed in the main to the effect of differences in soil of other environmental factors. Undoubtedly different varieties of oats differ greatly in their ability to adapt themselves to different environments. This fact is well recognized by the commercial seed growers. Statements are common in the literature to the effect that one variety is especially adapted to withstand a drought or will yield well on poor land, while another variety is described as especially adapted to rich soil, etc. Now the variety which will yield well under all kinds of conditions is in many cases a much more desirable variety for the average farmer than a variety which will yield higher but only under certain favorable conditions.

The data on the 1913 plots offer an opportunity to study the effect of such environmental influences. The data are by no means sufficient to warrant far-reaching conclusions. Experi-

ments involving a much larger number of plots for each variety or else carried on for a number of years would be necessary to settle such questions definitely. However these data together with certain other observations to be discussed later enable us to reach fairly definite conclusions regarding certain varieties.

What we wish to know in this connection is the amount of variation between the different plots of the same variety. Thus, that variety in which all four plots yield at nearly the same rate is, so far as we can judge from this experiment, less affected by the environment than a variety in which there is a wide difference in the yield of different plots. In order to measure this variation resort must be had to certain mathematical methods. Two mathematical constants may be calculated, viz., the standard deviation which measures the variation in absolute units and the coefficient of variation which measures the variability as a percent of the mean.[10] For comparative purposes it simply needs to be remembered that a variety with the smaller constant (standard deviation or coefficient of variation) is the less vari-

[10]For any readers who are unacquainted with the use of biometrical methods the following brief explanation may be of assistance.

The standard deviation denoted by the Greek letter sigma ($\varsigma$) is obtained by finding the difference between each observation and the mean of all the observations. These differences are then squared which makes them all positive in sign. The sum of these squared deviations is next divided by the number of observations ($n$) and the square root of this result is then obtained. The result technically expressed as the square root of the mean squared deviations is the standard deviation.

The formula is $\varsigma = \sqrt{\frac{\Sigma (D^2)}{n}}$, where $\Sigma (D^2)$ is the sum of the squared deviations. The standard deviation expresses the variation in terms of unit value, for example as bushels per acre in Table 7, or as pounds per bushel in Table 12.

In order to reduce this concrete value to a relative basis so that bushels may be compared with pounds resort may be had to the coefficient of variation. The coefficient of variation is obtained by dividing the standard deviation by the mean and multiplying the results by 100.

$$\text{Coeff. of variation} = \frac{\varsigma \times 100}{\text{mean.}}$$

This expresses the variation as a *percent* of the mean. It is the best method known of expressing the variation of a series of observations in a single mathematical term.

able and, therefore, within the limits of the experiment, less affected by differences in soil and environment."

Table 7 gives the average number of bushels per acre for the four plots of each variety in 1913. The probable error of this mean is also tabled. The last two columns of the table give respectively the standard deviation and the coefficient of variation for the yield of these plots together with their probable errors. The varieties have been arranged in the table in the order of the size of their coefficients of variation. The standard deviation in these cases run nearly parallel with the coefficients of variation so that in most instances the varieties are also in the order of their standard deviations.

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"In discussing the significance of such variation constants it is always necessary to take into account the statistical probable error to which they are subject. This probable error in no way takes account of any experimental errors. It simply tells us the amount of confidence, on the basis of chance, that can be put in the given constant. Thus we know that if we repeat an experiment a number of times under the same conditions we feel certain that the average of all the results gives a more nearly true value than any one of the results alone. The greater the number of the separate trials, the more confidence one can put in the average results. The probable error tells how much confidence we can put in the given result. It is of such size that the chances are equal that the true value lies within the limits obtained by adding and substracting the probable error from the calculated value. The probable error is always preceded by the plus or minus ($\pm$) sign.

The method of calculating the probable error of various constants is given in the current treatises on biometrical and statistical methods. A brief discussion of these is given in Part I of Bulletin 110, Bureau of Animal Industry, U. S. Dept. of Agr., pp. 22-24. 1910.

TABLE 7.

*Constants of Variation in Yield (Bushels per acre) for the Four 1913 Plots of Each Variety.*

| VARIETY. | Mean. | Standard Deviation. | Coefficient of Variation. |
|---|---|---|---|
| Imported Scotch | 67.66±0.81 | 2.40 ±0.57 | 3.54 ±0.85 |
| Lincoln | 65.94±1.11 | 3.28 ±0.78 | 4.97 ±1.20 |
| Abundance | 64.22±1.16 | 3.45 ±0.82 | 5.37 ±1.28 |
| Irish Victor | 67.03±1.22 | 3.63 ±0.87 | 5.42 ±1.30 |
| Kherson | 60.79±1.28 | 3.79 ±0.90 | 6.23 ±1.49 |
| American Clydesdale | 62.75±1.38 | 4.10 ±0.98 | 6.53 ±1.56 |
| Silver Mine | 57.81±1.28 | 3.78 ±0.90 | 6.55 ±1.57 |
| Minnesota No. 26 | 67.74±1.57 | 4.66 ±1.11 | 6.83 ±1.64 |
| Prosperity | 62.97±1.69 | 5.02 ±1.20 | 7.96 ±1.91 |
| Siberian | 71.10±1.87 | 5.55 ±1.32 | 7.81 ±1.87 |
| Early Pearl | 69.68±2.00 | 5.93 ±1.42 | 8.52 ±2.05 |
| Regenerated Swedish Select | 60.93±1.81 | 5.36 ±2.28 | 8.80 ±2.11 |
| President | 62.97±2.05 | 6.08 ±1.45 | 9.66 ±2.09 |
| Victor | 59.53±2.29 | 6.80 ±1.62 | 11.42 ±2.76 |
| Banner | 62.74±2.63 | 7.79 ±1.86 | 12.41 ±3.00 |
| White Plume | 63.44±2.84 | 8.41 ±2.01 | 13.26 ±3.22 |
| Garton No. 5 | 51.52±2.52 | 7.47 ±1.78 | 14.51 ±3.53 |
| Gold Rain | 65.16±3.25 | 9.64 ±2.30 | 14.79 ±3.61 |
| Rebred 60-Day | 54.38±3.35 | 9.93 ±2.37 | 18.26 ±4.50 |
| Daubeney | 52.19±3.51 | 10.41 ±2.48 | 19.95 ±4.94 |
| Senator | 51.72±4.28 | 12.68 ±3.02 | 24.51 ±6.19 |
| Average | 62.01 | 6.20 | 10.35 |

The mean yields for 1913 have been discussed in connection with Table 6. They are repeated here for convenience and also to give some idea of their probable errors.

The following points are brought out by this table:

1. The standard deviation ranges from 2.4 bushels per acre in the Imported Scotch to 12.68 bushels in the Senator. The average for all the varieties is 6.2 bushels.

2. These standard deviations are subject to probable errors ranging from one-half bushel to three bushels.

3. The coefficient of variation in the Imported Scotch is 3.54 percent and in the Senator it is 24.51 percent. As measured by the coefficient of variation the Senator plots in 1913 were seven times more variable than the Imported Scotch plots. The average coefficient of variation for all varieties is 10.35 percent.

4. Of the varieties tested in 1913 the Imported Scotch was by far the least variable. It may be stated here that so far as could be ascertained by observation the four Imported Scotch plots were grown under as widely different conditions as the plots of any other variety. It may, therefore, be tentatively

concluded that the Imported Scotch variety is much less affected by varying external conditions than are the other varieties.

5. The variety showing the next smallest variability is the Lincoln. The Abundance, Irish Victor, Kherson, Clydesdale, Silver Mine and Minnesota No. 26 all show comparatively small coefficients of variation. Under the conditions in 1913 the four plots of each of these varieties yielded at relatively uniform rates.

6. The varieties Banner, White Plume, Garton No. 5 and Gold Rain showed a large amount of variation. The Rebred 60-Day, Daubeney and the Senator showed an extremely large variability. These figures indicate that the yield of these varieties are very greatly affected by the difference in soil or other conditions which may be present in any field.

It must be pointed out again that the above conclusions are only tentative. Only four plots of each variety were used. It is always possible when such a small number is used that all four plots of one variety fell under much more similar conditions than the plots of another variety. In the course of time we hope to have this information for these varieties over a series of years. The present data would seem to indicate that the Imported Scotch is less affected by environmental changes than the other varieties, while the Senator is very greatly influenced by such differences.

## The Average Yield of Grain.

In the following paragraphs the average yearly yield of grain together with the variation in yield from year to year for each variety will be discussed.

Of the 41 varieties or strains listed in Table 1 only 11 have been tested for all four years. Of the remaining varieties a few have been tested three years and a number for two years. Those varieties which have been tested for only one year will be omitted from this discussion. For purposes of comparison the varieties which have been tested for four years will be tabled separately from the others.

### A. Varieties tested for four years.

Table 8 gives the yield of grain for the eleven varieties tested all four years. The varieties are arranged in the order of their

average yield for the four years. The yield of each variety for each year is given together with the four year means and their probable errors. Finally the standard deviations and coefficients of variation for each variety are given.

TABLE 8.

*Yield of Grain, Varieties Tested Four Years.*

| VARIETY. | BUSHELS PER ACRE. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1910 | 1911 | 1912 | 1913 | Mean. | Standard Deviation. | Coefficient of Variation. |
| Irish Victor | 70.5 | 55.6 | 61.6 | 67.0 | 63.68 ±1.90 | 5.64 ±1.34 | 8.85 ±2.13 |
| Imported Scotch | 60.0 | 62.4 | 62.2 | 67.7 | 63.08 ±0.96 | 2.83 ±0.67 | 4.49 ±1.07 |
| Lincoln | 70.0 | 47.7 | 68.3 | 65.9 | 62.98 ±3.01 | 8.94 ±2.13 | 14.19 ±3.45 |
| Prosperity | 65.5 | 52.8 | 67.4 | 63.0 | 62.18 ±1.89 | 5.61 ±1.34 | 9.02 ±2.17 |
| President | 68.2 | 49.5 | 61.5 | 63.0 | 60.55 ±2.31 | 6.85 ±1.63 | 11.30 ±2.73 |
| Banner | 70.8 | 45.8 | 62.6 | 62.7 | 60.48 ±3.07 | 9.10 ±2.17 | 15.05 ±3.67 |
| Silver Mine | 71.0 | 54.0 | 52.9 | 57.8 | 58.93 ±2.43 | 7.20 ±1.72 | 12.23 ±2.96 |
| Kherson | 69.4 | 47.8 | 52.7 | 60.8 | 57.68 ±2.82 | 8.37 ±2.00 | 14.51 ±3.53 |
| Victor | 59.5 | 54.5 | 56.9 | 59.5 | 57.60 ±0.70 | 2.08 ±0.50 | 3.61 ±0.86 |
| Regenerated Swed. Select | 72.1 | 40.9 | 56.5 | 60.9 | 57.60 ±3.78 | 11.19 ±2.67 | 19.43 ±4.81 |
| Senator | 53.5 | 38.3 | 53.5 | 51.7 | 49.25 ±2.15 | 6.36 ±1.52 | 12.94 ±3.14 |
| Average | 66.4 | 49.9 | 59.6 | 61.8 | 59.46 | 6.74 | 11.42 |

The yearly yields for these eleven varieties are displayed graphically in Figure 59.

From Table 8 and Figure 59 the following points may be noted.

1. The highest average yield of any variety for the four years was 63.68 bushels for the Irish Victor. The imported Scotch ranked next with 63.08 bushels. The Lincoln and Prosperity yielded at nearly the same rates. The President and Banner gave 60.5 bushels. The Silver Mine, Kherson, Victor and Regenerated Swedish Select averaged to yield at a slightly lower rate. The Senator shows the lowest yield, 49.25 bushels.

2. The average yield of these eleven varieties for the four years was 59.5 bushels. In 1910 these same varieties averaged 66.4 bushels per acre; in 1911 they averaged 49.9; in 1912, 59.6 and in 1913, 61.8 bushels. Thus the best yield was obtained in the first year. Further an inspection of Fig. 59 shows that with one exception (Imported Scotch) each of these varieties yielded as well or better in 1910 than in any other year. There are several possible reasons for this. In the first place the 1910 plots were seeded with two bushels per acre by *measure,* while

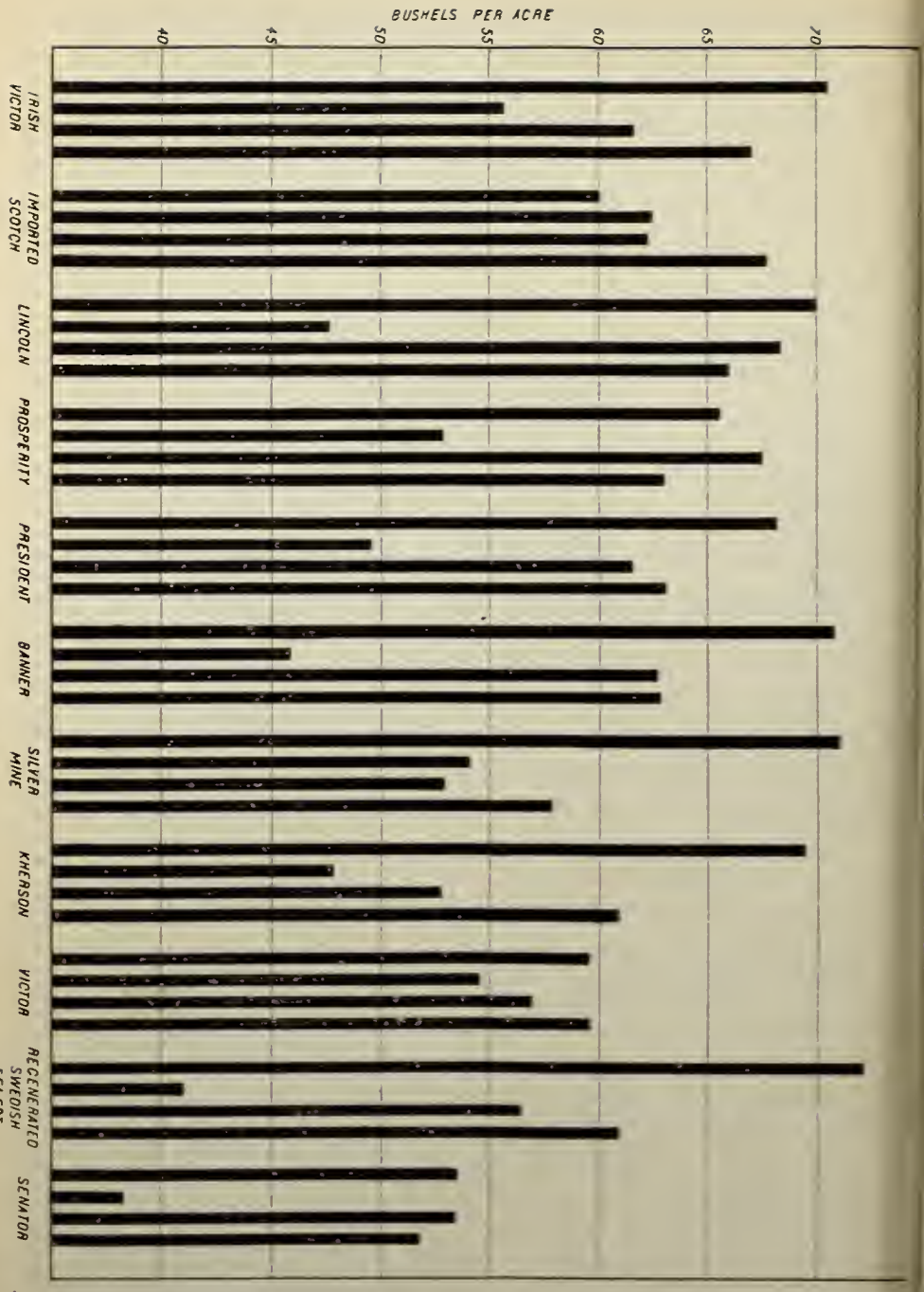


*Fig. 59. Showing the yearly yield of grain for each of the eleven varieties tested for four years. The varieties are arranged in the order of their average yield for the four years.*

in the remaining years the rate was two bushels by *weight*. It is possible that this difference in seeding accounts for the increased yield.

Another thing that may have influenced the yield is, that the seed of all these varieties was obtained in Canada and the Middle West. There is a persistent opinion among many farmers that foreign grown seed will yield better than home grown seed of the same variety. Where this question has been tested by experiments little or no grounds have been found for such a belief. For example the Iowa Experiment Station[12] tested twenty varieties by importing seed of each one, every year for three years and comparing with home grown seed. Their results show that on the whole the imported seed was no better than home grown. In fact the varieties usually did better after they had become acclimated by one or two seasons' growth in Iowa In view of these and other results we are not inclined to attach any significance to the suggestion that the better yields of 1910 were due to imported seed. As a matter of fact the results of the 1912 and 1913 tests contradicted this suggestion. The seven varieties imported from out of the state in 1912 all yielded very poorly in that year. In 1913, however, the majority of these varieties grown from our own seed yielded very well (cf. tables 5 and 6).

## INTER- AND INTRA-SEASONAL VARIATION.

The question of the reliability of the results of a series of variety tests is one which has attracted more or less attention. Recently Harris[13] has proposed the inter-plot correlation as a measure of the reliability of such tests. However, it appears to us that the variation constants (standard deviation and coefficient of variation) together with the probable error of the mean give a very desirable measure of the confidence which can be placed in the average of a series of such tests. These constants together with the mean production form a very good guide as to the desirability of a given variety.

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[12]Burnett, L. C. Some Data for Oat Growers. Iowa Agr. Exp. Sta. Bul. No. 128, pp. 93-127, 1912.

[13]Harris, J. A. On the Significance of Variety Tests. Science, N. S., 36, pp. 318-320, 1912.

In the long run the most desirable variety is that one which will give a high yield under any of the conditions that are likely to be met with in any season. A variety which yields very highly in a favorable season may not be so desirable as one which yields moderately well every year regardless of the season. The standard deviation and the coefficient of variation as given in Table 8 measure the amount of variation in the yield of a given variety for the four years. We have already discussed the variation in the 1913 plots in connection with Table 7. In any one year all the plots are subjected to the same seasonal conditions. When the yields of several seasons are compared we are taking account of the effect of differences in the seasons as well as of differences in the soil. It will be of interest to compare the variation of the plots in a single season with the variation during several years. For this purpose we may compare the two coefficients of variation for the eleven varieties discussed above. These constants have been brought together in Table 9. The varieties are arranged in this table in the order of their variation coefficients for the yield of the four years.

TABLE 9.

*Comparison of the Variation in Yield of the Plots in Four Different Years with the Plots in a Single Year.*

| VARIETY. | Coefficient of Variation for 4 years production. | Coefficient of Variation for the 1913 plots. | Difference. |
|---|---|---|---|
| Victor | 3.61 ±0.86 | 11.42 ±2.76 | −7.81 ±2.89 |
| Imported Scotch | 4.49 ±1.07 | 3.54 ±0.85 | +0.95 ±1.37 |
| Irish Victor | 8.85 ±2.13 | 5.42 ±1.30 | +3.43 ±2.50 |
| Prosperity | 9.02 ±2.17 | 7.96 ±1.91 | +1.06 ±2.89 |
| President | 11.30 ±2.73 | 9.66 ±2.09 | +1.64 ±3.44 |
| Silver Mine | 12.23 ±2.96 | 6.55 ±1.57 | +5.68 ±3.35 |
| Senator | 12.94 ±3.14 | 24.51 ±6.19 | −11.57 ±6.94 |
| Lincoln | 14.19 ±3.45 | 4.97 ±1.20 | +9.22 ±3.65 |
| Kherson | 14.51 ±3.53 | 6.23 ±1.49 | +8.28 ±3.83 |
| Banner | 15.05 ±3.67 | 12.41 ±3.00 | +2.64 ±4.74 |
| Regenerated Swedish Select | 19.43 ±4.81 | 8.80 ±2.11 | +10.63 ±5.22 |
| Average | 11.42 | 9.32 | +2.20 |

From this table we may first discuss the variation coefficients for the yield of the four years as given in the second column It will be noted:

1. That these coefficients vary from 3.61 percent to 19.43 percent. The average for the coefficients of the eleven varieties is 11.42 percent.

2. The Victor shows the lowest coefficient for the four years. The coefficient for the Imported Scotch is only slightly larger. These two varieties are by far the least variable in the four year test. So far as these data go they indicate that these varieties are much less affected by seasonal variations than any of the other varieties.

3. The Irish Victor and the Prosperity show roughly twice as much variation as the Imported Scotch.

The President, Silver Mine and Senator show variation coefficients in the neighborhood of 12 percent. They are nearly three times as variable as the Imported Scotch. The Lincoln and Kherson proved quite variable in the four year test with coefficients of over 14 percent. The Banner showed a variability of 15 percent of its mean, while the Regenerated Swedish Select gave a coefficient of 19.43 percent or more than 4 times as great as the Imported Scotch.

Comparing the coefficients of variation for the four years with those of the 1913 plots the following points may be noted.

1. The average coefficient for the eleven varieties is 2 percent higher for the four year yields than for the 1913 plots. Similarily with two exceptions (the Victor and the Senator) each variety shows a lower coefficient in the case of the 1913 plots. A difference in this direction is to be expected since, when all the plots are grown in one year, they are all subject to the same seasonal conditions. When different years are considered there are differences in the climatic conditions as well as in the soil. Hence it is to be expected that there would be a larger variation in the latter case.

2. The fourth column of Table 9 shows the difference between the two coefficients of variation for each variety. When the coefficients for the four years production is the greater the difference has been regarded as positive. From this column it will be seen that while the differences are often large numerically, in no case is a given difference as large as three times its probable error. It is customary in statistical work to regard the difference between two constants as not certainly significant unless the difference is at least three times its probable error.

Pearl and Miner[14] have recently pointed out that a deviation of three times its probable error may be expected to occur, on the basis of chance alone, more than 4 times out of a hundred trials. So that a deviation of even three times the probable error cannot be regarded as "certainly significant."

Consequently it is not possible to say of any individual variety that it is certainly more or less variable in the four year test than in the one year test. However, the fact that all but two varieties show a larger variability in the four year test and the fact that the sum of the plus differences is more than twice the sum of the minus differences tends to show that the results of tests made in different seasons are on the whole more variable than the results of tests made in a single year. As pointed out above this is what might be expected. Very probably a larger number of tests of each variety would show a significant difference in the coefficients.

3. The Victor which gave such a small variation in the four year test shows a very large variability in the 1913 plots. The difference between these two tests is 7.81 percent and the probable error of this difference is $\pm 2.89$ percent. The difference is not quite three times its probable error and cannot be considered as certainly significant.

In the case of the Senator the variation in the 1913 plots is again greater than that of the yearly production. In this case the difference is $11.57 \pm 6.94$ percent. Here, while the difference is large, it is less than twice its probable error and cannot be considered as statistically significant. It is quite possible that the plots of these two varieties were distributed in very unequal soil in 1913 and hence that their variation is relatively much larger than it ought to be. The results of future tests will help to settle this question.

4. The Imported Scotch shows practically the same variability in both cases. The difference between the two coefficients is much less than its probable error. On the whole the Imported Scotch has been much less affected by environmental conditions, whether inter- or intra-seasonal, than any of the other varieties.

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[14]Pearl, R., and Miner, J. R. A Table for Estimating the Probable Significance of Statistical Constants. Me. Agr. Exp. Sta. Ann. Rept. 1914, pp. 85-88. (Bulletin 226).

In addition it is an excellent yielder. It ranks second in point of yield in the four year test.

So far as the results of these tests go the Imported Scotch has proved itself the most desirable variety of any tested for all four years.

### B. VARIETIES TESTED TWO AND THREE YEARS.

There are eleven varieties that have been tested more than one year but less than four. It will be of interest to examine very briefly the average yields of these varieties and the amount of variation shown. Of course two or even three seasons is too short a time to judge the yielding ability of a variety. These data are given for what they are worth, simply an indication of what these varieties may do.

In Table 10 these eleven varieties are arranged in the order of their average yield per acre. The standard deviations and coefficients of variation have been calculated although in many instances the probable errors are so large that the constants have little meaning.

TABLE 10.

*Yield of Grain, Varieties Tested Two and Three Years.*

| VARIETY. | BUSHELS PER ACRE. | | | | | | Coefficient of Variation. |
|---|---|---|---|---|---|---|---|
| | 1910 | 1911 | 1912 | 1913 | Mean. | Standard Deviation. | |
| Early Pearl | – | – | 64.2 | 69.7 | 66.9 ±1.31 | 2.75 ±0.93 | 4.11 ±1.39 |
| Siberian | – | – | 50.0 | 71.0 | 60.5 ±5.01 | 10.50 ±3.54 | 17.35 ±6.03 |
| Minnesota No. 26 | – | – | 52.7 | 67.7 | 60.2 ±3.58 | 7.50 ±2.53 | 12.46 ±4.27 |
| Gold Rain | – | – | 53.8 | 65.2 | 59.5 ±3.20 | 6.70 ±2.26 | 11.26 ±3.85 |
| American Clydesdale | – | 55.0 | 54.5 | 62.8 | 57.4 ±1.48 | 3.80 ±1.05 | 6.62 ±1.83 |
| Abundance | – | – | 47.9 | 64.2 | 56.1 ±3.89 | 8.15 ±2.75 | 14.53 ±5.00 |
| White Plume | – | – | 44.1 | 63.4 | 53.7 ±4.60 | 9.65 ±3.25 | 17.97 ±6.25 |
| Early Champion | 66.1 | 39.1 | 50.4 | – | 51.9 ±4.31 | 11.07 ±3.05 | 21.33 ±6.14 |
| Rebred 60 Day | – | – | 47.5 | 54.4 | 50.9 ±1.65 | 3.45 ±1.16 | 6.78 ±2.30 |
| Danish Island | 46.7 | 47.5 | 57.7 | – | 50.6 ±1.95 | 5.01 ±1.38 | 9.90 ±2.75 |
| Daubeney | – | – | 43.3 | 52.2 | 47.7 ±2.10 | 4.40 ±1.48 | 9.22 ±3.14 |
| Average | 56.4 | 47.2 | 51.5 | 63.4 | 55.94 | 6.63 | 11.96 |

From this table it will be seen that the Early Pearl gave the best yield of any of these varieties. In fact its average for the two years of 66.7 bushels is larger than any of the four year averages in Table 8. It has given a better average for the two years that it has been tested than any other variety except the

Lincoln. Further it has shown very little variation in the two years. Its coefficient of variation, 4.11 percent, is practically the same as that of the imported Scotch for the four year period. All that can be said at present is that this is a very promising variety for our conditions.

A number of these varieties have averaged to yield very poorly. Four show an average yield of only about 50 bushels. Two of these varieties, the Early Champion and Danish Island, have been dropped from the test. The remaining two will be continued for comparative purposes.

## Yield of Straw.

Varieties of oats differ widely in the amount of straw produced from a given area. Further there is a great difference in the relation of the amount of straw to the amount of grain. The most marked differences in the yield of straw are between the early and late varieties. While in many cases the early varieties are able to equal the later ones in the yield of grain they show a much smaller yield of straw. In the following paragraphs the average yield of straw for the varieties tested four years will be discussed. The data relative to the straw yield of the other varieties are given in Tables 3 to 6, but will not be discussed farther in this bulletin.

The data relative to the yield of straw of the eleven varieties tested for four years are given in Table 11. The means, standard deviations and coefficients of variation have been determined for each variety. This table also shows the number of pounds of straw produced for each pound of grain for the averages of the four years.

## Table 11.

*Yield of Straw, Varieties Tested Four Years.*

| Variety. | Pounds of Straw per Acre. | | | | | Standard Deviation. | Coefficient of Variation. | Lbs. straw to 1 lb. of grain. |
|---|---|---|---|---|---|---|---|---|
| | 1910. | 1911. | 1912. | 1913. | Mean. | | | |
| Lincoln | 2990.0 | 2425.0 | 2942.0 | 3160.0 | 2879.3 ± 92.6 | 274.48 ± 65.45 | 9.53 ±2.29 | 1.43 |
| Banner | 2485.0 | 3350.0 | 2573.0 | 2872.4 | 2820.1 ±114.0 | 337.98 ± 80.60 | 11.98 ±2.90 | 1.46 |
| Irish Victor | 3120.0 | 2795.0 | 2254.0 | 3005.2 | 2793.6 ±112.0 | 332.60 ± 79.32 | 11.91 ±2.88 | 1.37 |
| Prosperity | 2875.0 | 2860.0 | 2693.0 | 2635.2 | 2765.8 ± 35.0 | 103.86 ± 24.77 | 3.76 ±0.90 | 1.39 |
| Regenerated Swedish Select | 2842.5 | 2190.0 | 3308.0 | 2674.0 | 2753.6 ±134.8 | 339.76 ± 95.33 | 14.52 ±3.54 | 1.49 |
| President | 2617.5 | 2615.0 | 3183.0 | 2475.2 | 2722.7 ± 91.7 | 271.94 ± 64.85 | 9.99 ±2.40 | 1.41 |
| Silver Mine | 2780.0 | 2370.0 | 3378.0 | 2310.0 | 2709.5 ±144.4 | 428.24 ±102.12 | 15.81 ±3 86 | 1.44 |
| Senator | 2487.5 | 2975.0 | 2567.0 | 2685.0 | 2678.7 ± 62.4 | 184.98 ± 44.11 | 6.91 ±1.66 | 1.70 |
| Victor | 2615.0 | 2455.0 | 2673.0 | 2715.2 | 2614.6 ± 33.3 | 98.75 ± 23.55 | 3.78 ±0.90 | 1.42 |
| Kherson | 2502.5 | 2970.0 | 1826.0 | 2585.2 | 2470.9 ±138.9 | 412.02 ± 98.26 | 16.68 ±4.08 | 1.33 |
| Imported Scotch | 2430.0 | 2602.5 | 2085.0 | 2635.2 | 2438.2 ± 73.7 | 218.42 ± 52.09 | 9.96 ±2.15 | 1 21 |
| Average | 2704.1 | 2691.6 | 2680.2 | 2704.8 | 2695.2 | 278.46 | 10.35 | 1.42 |

The mean yield of straw of these varieties is displayed graphically in Fig. 60.

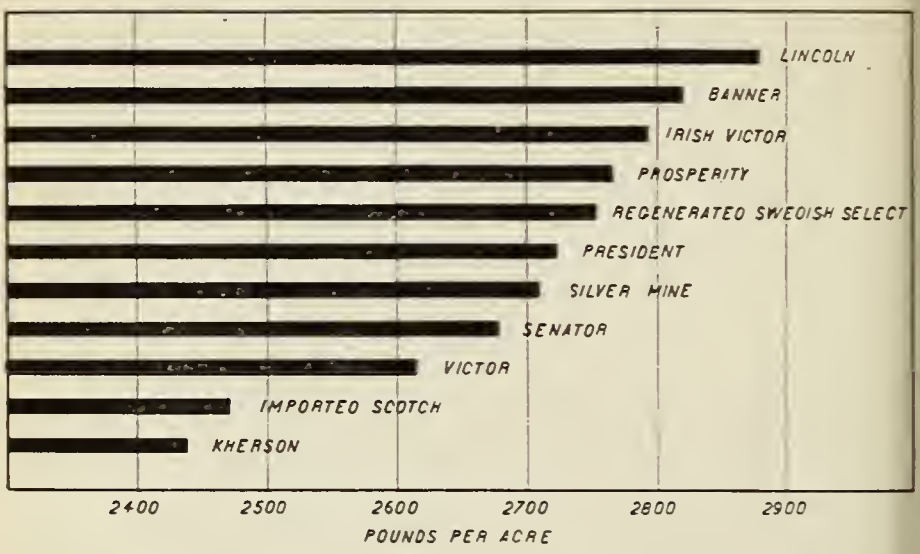


*Fig 60. Showing the average yield of straw for the four years 1910 to 1913 inclusive.*

From this figure it is seen that the Lincoln variety produced the largest amount of straw. The Imported Scotch and the Kherson produced the smallest amounts. Curiously enough the Victor which grows very tall produced a comparatively small amount of straw. Further this variety shows a very small amount of variation in respect to straw weight. Its coefficient of variation is 3.78 which is practically the same as its coefficient for yield of grain (Table 8).

The amount of variation in the yield of straw for the four years varies rather widely in the different varieties. The average coefficient of variation for all eleven varieties is 9.94 percent. Comparing with table 3 it is seen that these varieties are slightly less variable in respect to yield of straw than for yield of grain. The difference between the averages of the two sets of coefficients is 1.34 percent. This difference is subject to a rather large probable error and probably is of little significance.

The Prosperity and Victor show the smallest coefficients of variation for straw weight. The Senator comes next with a coefficient of 6.91 percent. The Lincoln and Imported Scotch have coefficients of 8.81 and 8.96 percent respectively. The Silver Mine and Regenerated Swedish Select proved to be the most variable.

In regard to the relation of straw to grain the average for all eleven varieties was 1.41 pound of straw to a pound of grain. The Senator gave as much as 1.7 pounds of straw to a pound of grain. On the other hand the Imported Scotch gave only 1.21 pounds and the Kherson 1.23 pounds.

### VARIATION IN THE WEIGHT PER MEASURED BUSHEL.

In tables 3 to 6 there is given the weight in pounds of a measured bushel of each of the varieties that have been continued in the test. These weights were obtained by using an ordinary two quart standard grain tester. Further the determinations were all made by the same method and by the same person (C. W. Barber). It has recently been shown by one of us[15] that variations in the method of taking bushel weights may affect the result very materially. The method used in these varieties was to pour the grain into the tester, shake the tester five times and then stroke with a zig-zag movement. This method gives a slightly higher average weight (ca. 1.6 pounds per bushel) than the usual method but it has the great advantage of being subject to much less random fluctuation and hence a smaller probable error. (Cf. Barber *loc. cit.*).

It has further been shown that tested on 100 samples of Lincoln oats this method gave a standard deviation of $0.3245 \pm .0110$ pounds. On the basis of this result we would not expect to get deviations of more than one pound from the mean in either direction in any sample drawn from the same lot of seed and measured by this method. Consequently differences in the bushel weight of one pound or more indicate clearly a difference in the character of the oats.

In all cases the oats have been run through the fanning mill once before the bushel weights were determined. Of course it is not always possible to run different lots of seed, especially in different years, through the fanning mill in exactly the same way. However, it appears that only in exceptional cases would the difference in fanning make as much as one pound difference in the bushel weight of a given sample.

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[15]Barber, C. W. Note on the Accuracy of Bushel Weight Determinations. Me. Agr. Exp. Sta. Ann. Rept. 1914, pp. 69-75. (Bul. 226).

We may next examine the data relative to weight per bushel on the eleven varieties tested for four years. The average weights per bushel for each variety and each year are brought together in Table 12. The means, standard deviations and coefficients of variation for the four year tests are also given. In the case of the 1912 crop the weight per bushel of the early seeded plots are given, rather than the average of the two plots for each variety. It has already been pointed out that the late seeded plots showed a much lower bushel weight than the early seeded ones. It is well known that the bushel weight of oats is very markedly affected by different climatic and seasonal conditions. Since the early seeded plots of 1912 correspond in time of seeding and other conditions with the plots of other years it seem desirable to use these rather than an average of the two.

TABLE 12.

*Weight per Measured Bushel.*

| VARIETY. | POUNDS PER BUSHEL. | | | | | | Coefficient of Variation. |
|---|---|---|---|---|---|---|---|
| | 1910 | 1911 | 1912* | 1913 | Mean. | Standard Deviation. | |
| Regen. Swed. Select | 44 0 | 42.8 | 43.3 | 35.1 | 41.30 ±1.21 | 3.60 ±0.86 | 8 71 ±2 09 |
| Victor | 41.6 | 41 7 | 42 9 | 36 8 | 40.75 ±0 79 | 2 34 ±0.56 | 5 74 ±1.37 |
| Silver Mine | 39.4 | 39.8 | 42 2 | 36.8 | 39.55 ±0 65 | 1.92 ±0 46 | 4 85 ±1.09 |
| President | 40.0 | 41 6 | 37.3 | 35 8 | 38.67 ±0.76 | 2.26 ±0.54 | 5.84 ±1.40 |
| Prosperity | 38.9 | 39.2 | 39.2 | 36 7 | 38 50 ±0.35 | 1.04 ±0 25 | 2 70 ±0 64 |
| Lincoln | 40.4 | 40 0 | 39.7 | 33.3 | 38.35 ±0.99 | 2 93 ±0 70 | 7 64 ±1.83 |
| Senator | 40.8 | 41.5 | 37 2 | 32.4 | 37.97 ±1 21 | 3.60 ±0.86 | 9 48 ±2 28 |
| Banner | 39.7 | 39 8 | 37 7 | 34 3 | 37 87 ±0 75 | 2 22 ±0 53 | 5 86 ±1 40 |
| Irish Victor | 37 9 | 36.9 | 39.0 | 36 1 | 37.45 ±0 38 | 1.12 ±0 27 | 2.99 ±0.71 |
| Imported Scotch | 34.8 | 36.4 | 36 7 | 34 9 | 35.70 ±0.29 | 0.86 ±0 21 | 2 41 ±0.57 |
| Kherson | 30.2 | 33.1 | 35.3 | 36 2 | 33 70 ±0.79 | 2.33 ±0.56 | 6 91 ±1.66 |
| Average | 38.88 | 39 34 | 39 14 | 35 30 | 38 16 | 2 22 | 5 74 |

*Early seeded plots only.

From table 12 it is seen:

1. That the average weight per bushel for all varieties for all four years is 38.16 pounds. The Regenerated Swedish Select and the Victor averaged to weigh the most per bushel. The Imported Scotch and Kherson show the smallest weight per bushel.

2. In the first three years there was very little difference in the average weight per bushel of these eleven varieties. The highest average was in 1911 (39.34 lbs.) and the lowest in 1910 (38.88 lbs.). The difference is less than one-half pound.

3. In 1913, however, there was a very decided drop in the bushel weight of all varieties except the Kherson. The average of all eleven varieties in 1913 was only 35.3 pounds. This is a decrease of nearly 4 pounds from the averages obtained in the other years. This decrease in bushel weight in 1913 is probably due to the seasonal conditions. The weather was very dry during the time that the grain was filling. Further the 1913 plots were on lighter soil which dried out more quickly than the plots of other years. It seems probable that these conditions caused the lighter weight.

4. It is of interest to note that the Kherson variety showed an increase in weight in 1913. This may be accounted for by the fact that the Kherson matures earlier than the other varieties and hence formed its grain before the dry weather.

5. It is further of interest to note that the Kherson oats show a progressive increase in the weight per bushel. In 1910 this variety weighed only 30.2 pounds per bushel; in 1911, 33.1; in 1912, 35.3 and in 1913, 36.2 pounds. Thus in 1913 the Kherson was among the heaviest oats grown. Whether this change is simply a fluctuation due to seasonal conditions or whether the variety is being changed by its growth under Maine conditions cannot be ascertained at present. It will be of interest to follow the bushel weight of this variety in later years.

6. The average standard deviation of these eleven varieties is 2.2 pounds and the average coefficient of variation is 5.74 percent. Comparing this coefficient of variation with those for grain and straw weight of the same varieties (Tables 8 and 11) it is seen that they are considerably less variable in bushel weight than in other characters.

7. The Senator and the Regenerated Swedish Select show the largest variability for the four years. The Prosperity, Irish Victor and the Imported Scotch show the least variability. In the latter variety the standard deviation is less than seven-eights of a pound and is not beyond the limit of experimental error.

It is of interest that the Imported Scotch which was one of the least variable varieties in respect to other characters also shows the smallest variability in regard to bushel weight. In all of its characters this variety has proven itself to be one of those least affected by external conditions.

## Summary and Conclusions.

The present bulletin is one of a proposed series of papers on breeding and inheritance in oats. This paper deals with the results of the tests of commercial varieties of oats which have been carried out during the past four years. The object of these variety tests is first to find out which of the more popular commercial varieties of oats are best adapted to our conditions and second to furnish material for further breeding operations with this crop.

These variety tests have been carried on for four years. It is realized that this is too short a time to draw final conclusions regarding the comparative value of the varieties. However, the data already obtained offer certain indications which should be of much value to those farmers who are looking for better varieties than they already have.

In the present bulletin the character of the soil and the methods of growing and handling of the crop are discussed in detail. The source and the chief characters of each variety used are given. A more detailed description is given of some of the more important varieties.

In 1910 and 1911 each variety was grown on a single one-tenth acre plot. In 1912 duplicate one-tenth acre plots were used. In 1913 each variety was grown in four one-fortieth acre plots. These plots were distributed over the field in a regular manner so that differences in the character of the soil were more evenly distributed among the different varieties.

Tables 3 to 6 inclusive give the detailed data regarding each plot grown. For the years 1912 and 1913 the averages of the several plots of each variety are also given.

During the four years, thirty-four differently named varieties have been tested. In some instances several strains of the same variety have been tested. In most instances such strains differed very markedly from each other in their yielding abilities. For example as shown in Table 3, four strains of the

Banner variety were tested in 1910. These strains came from widely separated provinces in Canada. The strains from Alberta and Saskatchewan yielded much better than the strains from Ontario and New Brunswick.

Of the eleven varieties which have been tested for all four years the Irish Victor gave the best average yield (63.7 bushels per acre). The Imported Scotch, Lincoln and Prosperity averaged to yield at nearly the same rate. The Senator, a horsemane oat, with very coarse straw and large plump grains, gave the lowest average yield (49.3 bushels).

A study of the variation constants (standard deviation and coefficient of variation) for the four year period shows that the Victor (a black oat) and the Imported Scotch were by far the least variable of any of the varieties tested. This indicates that these varieties are much less affected by seasonal differences than the others. Further as shown in Table 7 the Imported Scotch shows less variation between its four plots in 1913 than any of the other varieties. Consequently the present data indicates that the yield of this variety is less affected by environmental conditions than that of the other varieties tested.

It is pointed out in this paper that the variation constants measure a very important character of a variety. A variety which will yield very highly under favorable conditions but very poorly under unfavorable ones is not so desirable in the long run as a variety which will yield moderately well under any of the conditions that are likely to be met in any season. Further the variation constants and the probable errors calculated with their aid give a very desirable measure of a series of tests.

The yield of straw and its variability in the four years is discussed. Also the relation between the amount of straw and the amount of grain is shown in Table 11. The Lincoln, Banner, and Irish Victor gave the largest average yield of straw. The Imported Scotch, Kherson and Victor gave the smallest amounts of straw. The Senator and the Regenerated Swedish Select gave the largest proportion of straw to a given weight of grain.

while the Imported Scotch gave the smallest relative amount of straw.

The weight per measured bushel is shown in Table 12. The Regenerated Swedish Select and the Victor gave the highest average weight, about 41 pounds per bushel. The Kherson and the Imported Scotch gave the lowest weight per bushel. These were still well above the legal weight of 32 pounds. It is of interest to note that the Kherson shows a progressive increase in its weight per bushel for the four years that it has been grown in this state.

In addition to the eleven varieties tested for four years, three varieties have been tested for three years; eight varieties for two years; and one variety for one year only. Two or even three years is too short a time to get a reliable measure of the yielding ability of a variety. However the data for the yields of these varieties are summarized in Table 10.

Of the eight varieties introduced in 1912 seven were from Canada and the middle west. None of these varieties gave satisfactory yields in 1912 although a number of them did very well in 1913. The eighth variety, the Early Pearl, originated in Maine and it yielded very well the first year.

These data indicate that possibly there is an advantage in having varieties that are acclimated to the conditions under which they are to be grown.

Of the varieties which have been tested for four years the Irish Victor, Imported Scotch, Lincoln and Prosperity have made the best showing. With the exception of the Imported Scotch there appears to be but little choice between these varieties. The Imported Scotch has shown much less variability in respect to all its characters (with the exception of straw weight) than any of the other varieties. This is true both of inter-and intra-seasonal variation. Under the conditions of seeding and growth at Highmoor this variety can be expected to produce a little over 60 bushels per acre every year. The chief objections to this variety are its relatively small weight per bushel and the yellow color of its grain. This latter objection is not very serious although yellow oats do not meet with so much favor on the market as the white varieties.

The other three varieties named above are more variable in their characters but nevertheless they appear to be very well adapted to our conditions.

Of the varieties tested less than four years the Early Pearl appears to be the most promising. The Siberian and Minnesota No. 26 also yielded very well in 1913.

It is expected to continue these tests and to publish the results from time to time. The performance of these varieties will form a standard with which the yield of new varieties originated in our breeding work may be compared.